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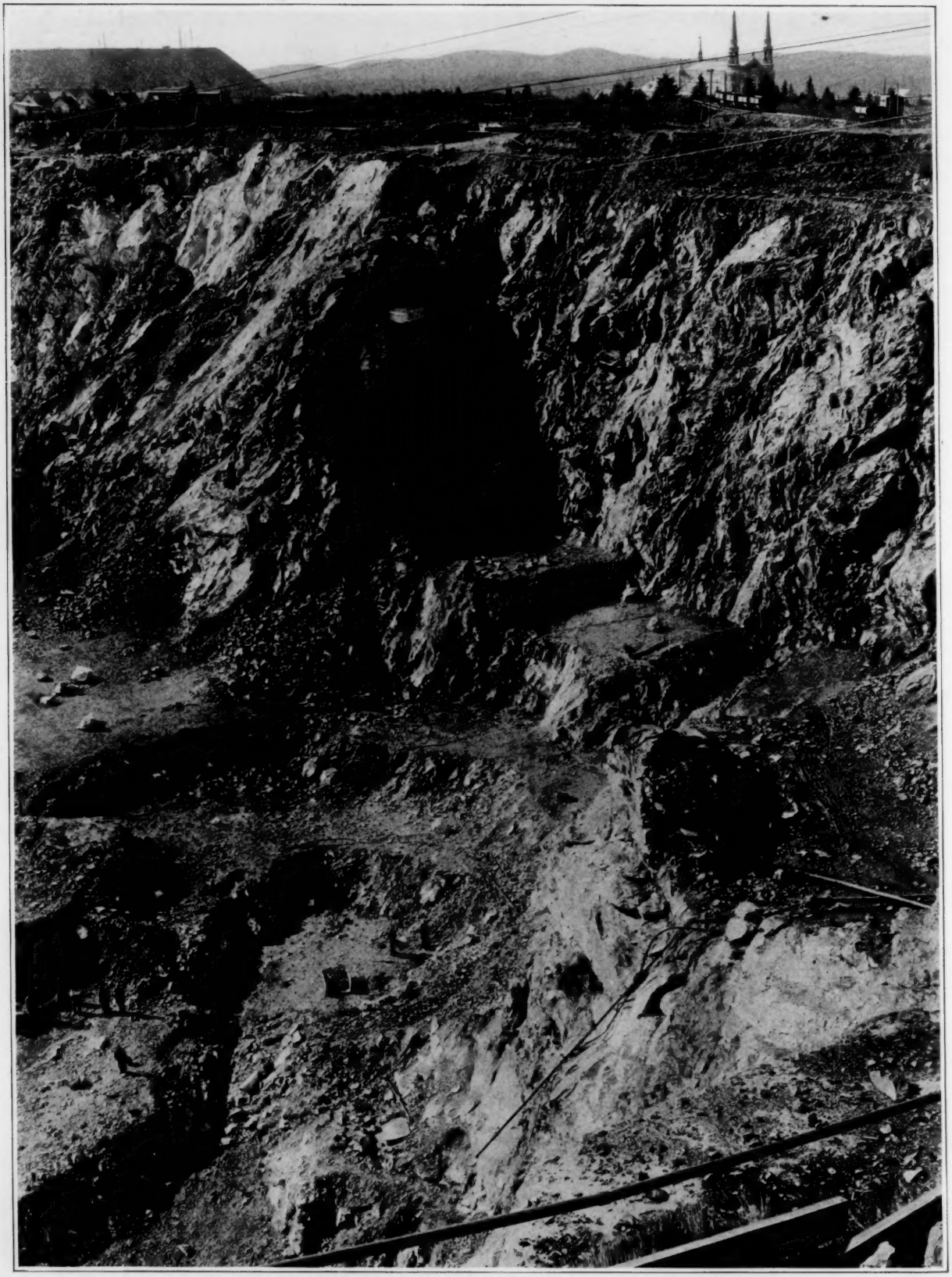

A TYPICAL EXAMPLE OF THE OPEN-CUT METHOD OF MINING ASBESTOS IN QUEBEC

Note the human figures in the left foreground, giving an idea of the size of these stripping operations. (See page 245)

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FAMILIARITY BREEDS CONTEMPT

WHEN we were young and still in possession of many of the illusions of youth, we recall that one of the things about which these illusions were particularly strong was the Constitution—Federal or State, as the case might be. When we read in the morning paper that this or that enactment had been adjudged by the court of last resort to be unconstitutional, we had a very definite picture of the deep humiliation of the legislature that had passed the offending statute. It must be weeks, we supposed, before the cloud would be entirely dispelled; and we wondered whether the individual drafter of the objectionable act would ever be the same again.

The manner in which we lost this particular illusion is part of the story. We were employed for a few months as office boys in a larg law firm, one member of which specialized heavily in arguing appeals. In the library one fine morning we overheard him in consultation with another of the partners, one of whose cases was having a rough time of it in the lower court. They agreed that there was little hope of an immediately favorable decision, since the law seemed pretty definitely against their client. Then, while we wondered when and how they would break the news to this unfortunate creature, the junior member remarked, "Well, that leaves just one way out when the case comes into your hands." "Yes," the senior responded nonchalantly: "we shall have to attack the constitutionality of the law." Just like that: as casual as asking the umpire to throw out a damaged ball.

This little tale, it seems to us, has direct bearing upon the attitude of the insider and that of the outsider in any field of endeavor. The proverb which we have set down at the head of this column runs through all human affairs. The physicist may look with a good deal of respect upon what he supposes to be the mathematician's sacred structure of Euclidean geometry; but his own fundamentals he revises again and again with ruthless hand, to make them better suit the passing needs of the moment. He overthrows the entire structure of physics and philosophy in order to replace this edifice with a new one in better harmony with what the outsider would be inclined to regard as a few rather insignificant experiments, whose explanation might well be left open.

In the same way and with few exceptions indeed, every science is today in an extremely open-minded attitude toward its own fundamentals—more ready to revise them than the watching world is to have them revised. And to be sure, is not this well? The old proverb has a ring of reproach; but it was writ when illusions bulged large in the mental equipment of the human race. Better that familiarity should make us contemptuous of our accepted scientific doctrine than that too great respect should breed in us the dogma which has so impeded progress in the past.

"ENGLISH AS SHE IS SPOKE"

THERE is noticeable today a growing tendency to assume that the language is ours, to do with what we will. It is of course true that in many respects consensus of usage makes good usage. Words come to mean things far from their original significance, simply because we insist upon using them in such meanings. Pronunciations as regards both single words and general principles, change widely with the passage of years. Even farther than this it is proper to go; anything that savors in the least degree of convention we should be free to alter if we wish.

For instance: there really is no very good reason why we should insist upon using the predicate nominative. It is entirely reasonable to say that the substantive in the predicate ought to agree with the subject; it is equally reasonable to insist that all verbs, transitive or otherwise, ought logically to be followed by the same form. No less an authority than Professor Lounsbury of Yale looked forward to a time when we should all say "It is him."

Again, just as English and French differ in this point, so do they differ in many others. The Frenchman says "without to go," "for to act," where we say "without going" and "for acting." The choice between infinitive and participle (or gerund, if you insist on calling it that) is purely a matter of convention, and is subject to change. The German, if we translate him literally, writes a book "over" the thing he has on his mind instead of "about" it; and his use of "an" and "bei" is absurdly at variance with our handling of their cognates. He uses "through" to indicate the agent with the passive verb where we employ "by." All these usages, and in fact the choice of almost every preposition, are matters of pure convention and entirely subject to variation at our pleasure. Even the manufacture of a new word through the juxtaposition of "on" and "to" we can effect if enough of us insist upon it.

All this and much more is proper; the minute we get a majority on the side of change, the new expression becomes automatically correct. But there are some things that no majority can ever do to our language. The New York *Tribune* and some unidentified member of the English faculty of Columbia University to the contrary notwithstanding, "else" is an adverb and not a pronoun. It takes more than mere consensus of usage to make a pronoun of it, and to bestow a possessive case upon it, so that we could say "some one else's" without laying ourselves open to the retort "which Elsie?" Some millions of Southerners to the contrary notwithstanding, "like" is a preposition and not a conjunction; we can do things *as* some one else *does* them, or we can *act like* this some one else, but we can never do things *like* he *does* them without murdering the English language. Similarly in the case of "without" vs. "unless." And these are but a few examples out of many.

The Size of the Galaxy*—I

New Results from a Study of Star Clusters and the Structure of the Universe

By Harlow Shapely, Ph.D., Mount Wilson Observatory

From time to time, in his monthly contributions to the SCIENTIFIC AMERICAN *(the regular weekly edition), Dr. Russell, himself one of the world's leading astronomers, has told our readers something of Dr. Shapely's monumental work in the examination of the size and structure of the universe of stars. Dr. Shapely of course has himself put his findings into print, but not, we believe, before a general audience. It accordingly affords us gratification to give him space for a discussion of what he regards as the outstanding features of his investigations of so many years.*—THE EDITOR.

THE modern investigation of the origin and structure of the sidereal universe is a problem for the ordinary branches of physics rather than, as in times past, a subject wholly within the realm of metaphysics and theology. The application of the principles and methods of the physical sciences to the study of sidereal conditions—the science of Astrophysics—is at the basis of our researches into the arrangement of the stellar system, its past and its future history. We measure light, mass, time, and length, the most important for our present problem being length—that is, the distances and dimensions of the various celestial objects.

Our conceptions of the dimensions and structure of the galactic system necessarily change with time. The evolution of cosmic interpretations must keep pace with the growth of the great observatories, with new developments in physics and astronomy. Until recently we have been content to believe our disk-shaped Galaxy but a few thousand light-years in greatest diameter (a light-year is the distance light travels in a year—about six million million miles); various studies of stellar clusters and of faint variable stars, however, indicate that the system is several thousand times more voluminous than previously thought. An account is presented in the following pages of some methods and results of my work on variables and clusters in so far as they bear on the size of the Galaxy.

Since with advancing knowledge of the stars the distances increase in the known sidereal universe, the futility of our ordinary procedure in fathoming the depths of space grows more apparent. A thousand stars are within the reach of the usual triangulation methods; thousands of millions are hopelessly remote.

The need of more powerful and expeditious ways of measuring sidereal distance has led astronomers to various devices. The usual trigonometric (triangulation) method consists in observing the position of a star in the sky at different times of the year, commonly when the earth, as seen from the star, has maximum angular distance from the sun. Greater numbers of stars may be reached through using as a base line for triangulation not the diameter of the earth's orbit as in the method mentioned, but the ever-accumulating distance, due to the motion of the whole solar system through space. Statistical analysis of stellar motions across the surface of the sky and in the line of sight have given us average distances of large groups of brighter stars. A spectroscope method devised by Adams and Kohlschütter permits the determination of the distance of most types of stars for which spectra of sufficient dispersion can be obtained.

I. THE RÔLE OF VARIABLE STARS IN THE MEASUREMENT OF GREAT STELLAR DISTANCES

The study of two kinds of variable stars, however, yields results that allow us to reach farther into space than has heretofore been within our power. The distances of certain objects, so remote that they are scarcely visible with the greatest telescopes, can now be deduced with accuracy, and considerable steps can be made toward a better appreciation of the extent of the sidereal universe. The following paragraphs are devoted to a discussion of the methods of measurement that are based upon studies of the brightness of variable stars.

The principles involved in the determination of stellar distance through measures of the quantity of light are very simple. As an illustration let us consider a series of street lamps observed visually (or photographically) from a fixed station. Suppose the lamps are all of the same candle power. To the observer, the near ones will appear bright, the distant ones faint, the brightness decreasing as the square of the distance increases. If one of these equally luminous lamps is ten times as far away as the nearest, the observer receives from it but a hundredth as much light; and it is fainter by five magnitudes, if we express the relative amount of light in the ordinary astronomical units. When the observer measures the quantity of light received from each lamp, he can compute immediately their relative distances; and then, if he determines by triangulation or some other direct method the actual distance to the nearest lamp, he may compute at once the actual distances of all the others.

The problem of distance is the same for street lamps and variable stars. We find from studies of motion, light variation, color, and spectrum how to estimate the actual candle power of the different stars. Then through ordinary methods of astronomical photometry we measure the quantity of light received from a star—its apparent brightness—and easily derive the distance. In other words, this comparison of their actual (absolute) brightness with the brightness they appear to have is a key to the distances of stars. By definition, the absolute and apparent magnitudes are the same at a distance of 32.6 light-years. A simple formula states the numerical relation between length and light. If M is the absolute magnitude and m is the apparent magnitude, then the distance, d, expressed in light-years, is given by

$$\log d = 1.514 - 0.2\ (M - m).$$

The most distant objects, which are of highest importance for studies of the structure and extent of the universe, are of course extremely faint. In fact, some of the stars that are involved in my investigations of clusters are more than 100,000 times fainter in apparent brightness than the faintest stars visible with the unaided eye.

Stars vary in light, position, velocity, color, and other properties; ordinarily, however, when we speak of variable stars we mean only those that vary in brightness. An important and numerous variety of variable stars is the eclipsing binary—a double star whose components move in an orbit inclined at such an angle that, to the observer on the earth, the light is periodically and temporarily diminished through eclipses. Algol, the second brightest star in the northern constellation Perseus, is the best known member of the class. The systematic study of the brightness of such a double star permits the astronomer to derive a light-curve, that is, a plot of magnitude against time, showing the variation of the light throughout the course of a complete revolution in the orbit.

*Adapted by the author from a series of articles published in *Scientia*, October, November, 1919, February, March, 1920.

In the most favorable cases as many as a dozen independent properties of the eclipsing binary and its orbit may be obtained from a mathematical study of the light-curve. A similar number of interesting dependent quantities may be derived, among them the absolute brightness of the component stars—the quantity that is important for our studies of the structure of the universe—for, as stated above, when we know the actual brightness, the easily determined apparent brightness immediately gives us the distance.

The absolute magnitudes and distances of nearly a hundred eclipsing stars have now been computed as by-products of the study of the stellar orbits, and it is found that a distinct advance has been made over direct measures of distance. Of the ninety variables whose parallaxes have been derived and discussed by Russell and Shapely, two-thirds are more distant than a thousand light-years, quite beyond the sphere of accurate measurement by trigonometric methods, and a number of them are more than five thousand light-years away.

The inferiority of our sun as a light source, when compared with many of the naked-eye stars, is frequently noted by astronomers. As a class, eclipsing binaries also are intrinsically very bright relative to the sun. Although some exceed its candle power but little, most of them are from ten to a hundred times as luminous, and many emit a thousand times the equivalent of the solar radiation. In fact, the so-called dark companions in eclipsing systems usually far exceed our sun in size and in total radiance.

Similarly, the Cepheid variables (these receive their name from Delta Cephei, the first known variable star of the kind) are giants in absolute brightness. They are always, in fact, more luminous than a hundred suns, and those which are equivalent to a thousand suns are typical members of the class. Much attention has been given this type of variable in recent years. They are known to vary periodically and synchronously in color, spectrum, and apparent velocity, as well as in stellar magnitude. They seem to be single stars, rather than binaries, and their variations are interpretable as periodic pulsations in gigantic volumes of luminous gas. The period of pulsation is in some cases but a few hours, in others, several days or weeks; but for any given star the period is usually constant within a small fraction of a second. A quick rise to maximum light, followed by a slower decline to minimum, characterizes the typical Cepheid light-curve.

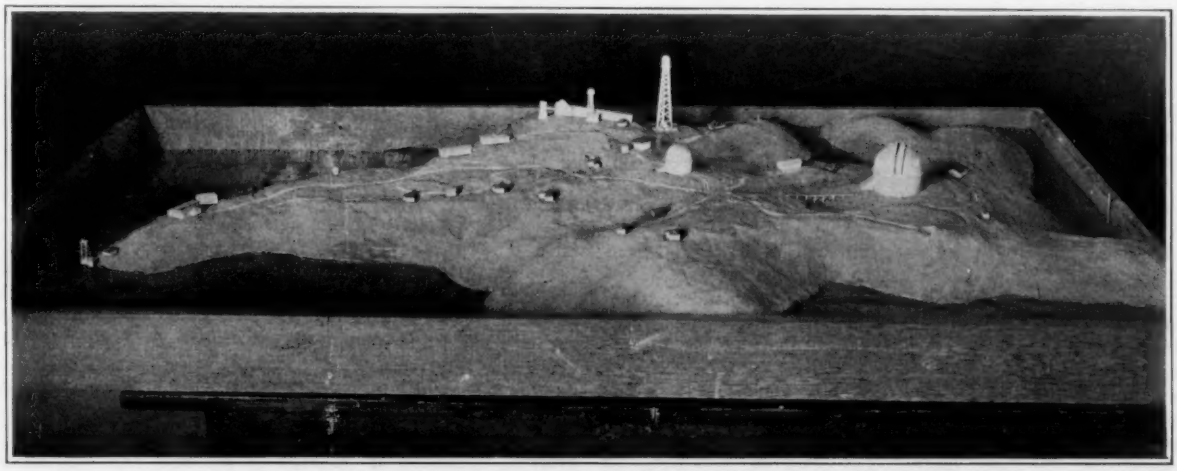
Because of their very high importance in problems of sidereal distance, and their peculiar bearing on questions of the dynamics of stellar evolution, no class of stars is of greater significance in modern stellar astronomy than the Cepheid variables. The determination of their absolute magnitudes and distances is a much more direct and accurate process than for eclipsing binaries. In place of the complicated relations between spectrum, period, dimensions of the stars, and relative luminosities, which enter the orbital theory for eclipsing stars, we need only the period of light variation to get the absolute magnitudes of Cepheids.

Some years ago Miss Leavitt at the Harvard College Observatory pointed out that for 25 Cepheid variable stars of the small Magellanic Cloud the length of the period of variation depends upon the *apparent* brightness. The periods range from two days to more than three months. Since the variables in the Cloud are all at essentially the same distance from the earth, the correlation is actually between *absolute* brightness and period of variation.

The work on clusters and variable stars during the last few years at Mount Wilson permits the development of this correlation into an instrument of much usefulness. The period-luminosity relation has been accurately defined throughout the whole interval of brightness, spectrum, and period in which Cepheids occur. Variables from many globular clusters and from the scattered stars of the Milky Way have been analyzed as to light-curves and periods. The motions and measured distances of the relatively near stars of this class have been utilized to establish for all Cepheids the scale of distance in terms of known units. The result is a definitive curve, connecting absolute magnitude with the logarithm of the period; it shows that the more luminous the variable, the longer its period, and that the least luminous have periods shorter than a day.

As soon as variable star observers have derived the period and apparent magnitude of a Cepheid, the absolute magnitude may be read from the period-luminosity curve and the distance computed with the aid of the formula given above. Thus the remarkable physical properties of a luminous gas, which closely unite the actual brightness of giant stars with the period of pulsation and variation, give the position in space of all known Cepheids. Though actually very bright, many appear extremely faint because of distance. Cepheid variables, therefore, as well as eclipsing stars, permit us to go out much farther into space than we had hitherto gone.

It is not, however, in exploring the immediate vicinity of the sun that these variable stars contribute so much to knowledge of the structure of the universe. It is rather through their frequent occurrence in other remote stellar organizations, such as globular clusters, that they aid greatly in surveying the sidereal system; for it is clear that, in giving us their own distances, the variables in clusters are at the same time revealing the distances of the vast assemblages of which they are members. In this manner they show us the distribution of objects so remote that, to reach our earth, their light must



PLASTER MODEL OF THE TOP OF MOUNT WILSON, SHOWING THE OBSERVATORY

The 100-inch and 60-inch reflectors are located within the two largest domes. The tower telescopes are used in solar investigations. Model and photograph by F. Ellerman

travel many thousands of years across the intervening emptiness of sidereal space.

II. GLOBULAR CLUSTERS AS COSMIC UNITS

Among the stars social relationships are nearly as common as among men and the lower animals. Sidereal bodies that are completely independent of all star societies are difficult of conception; for the immediate environment, as well as the heritage of early and ancestral association, influences the present behavior and the destiny of stars. Planetary systems, binaries, groups of three or four nearly equal bodies, are thought to be very common—almost universal, it may be; and the assemblage of stars of all kinds by the tens, hundreds, and thousands into physically organized clusters now appears to be a property of fundamental significance in stellar investigations.

In considering the aspect of clustering among the fixed stars we see a gradual progression from the largest and most scattered constellations to such rich and highly concentrated stellar groups as the globular clusters. Although the constellations were outlined for the most part in prehistoric times and have been used in myths and astrology for thousands of years, they do not in general represent definite physical organizations that exclude the stars of neighboring groups; and frequently even the legendary relationships of the stars in the most anciently known constellations are traced with difficulty.

There is, however, among the varied groupings, an easy transition from widely-scattered Ophiuchus and Camelopardalis to Orion, Scorpio, and the Great Bear; and in recent years we have found that the most conspicuous stars of these three last-named constellations actually form physical stellar systems. The stars of each have motions, colors, and distances in common, and in each case they have evolved, no doubt, from an origin common in space and in time. From Orion we readily trace the progression in clustering to the Hyades—a more compact and more definitely circumscribed dynamical system—and then to the Pleiades, to Praesepe, to the double cluster in Perseus, and to similar faint loose clusters of the Milky Way; thence, by way of Messier 11 and Messier 22, we proceed by nearly equal steps to typical globular systems exemplified in the great Hercules cluster, Messier 13.

Although we may justly restrict the term star cluster to physical systems—that is, to groups which have the characteristics of distinct dynamical organization—it is clear that the subdivisions of the long sequence from Orion to the Hercules cluster must necessarily be vaguely defined. For convenience we here distinguish only open and globular clusters, and designate all as open except those eighty or ninety highly condensed groups whose stars appear innumerable even with the aid of our largest telescopes and most sensitive photographic plates.

Open and globular clusters, however, differ in matters other than richness and apparent circularity. In average distance from the earth the globular clusters much excel, in stellar constituency they are more varied, and we recognize that, from a dynamical point of view, in their wide spatial distribution the globular clusters are quite distinct from the open groups which closely congregate along the middle line of the Milky Way.

In the second paper of this series it will be shown that most of the globular clusters are isolated systems, neither intermingled with nor closely surrounded by other stars. They may be treated, therefore, as distinct cosmic units. Their ultimate destiny, to be sure, may be disintegration and dispersion throughout wide regions of sidereal space. Their careers as distinct self-governing units may end, as the later discussion will show, by the absorption of all of them into a sidereal federation that is greater, more powerful, and more permanent; yet the form, content, and other characteristics of globular clusters at the present time constitute a fairly legible record of conditions that have existed for many millions of years—a record, moreover, of a stage that appears to be representative and fundamental in the slow evolution of sidereal organization.

In treating globular clusters as individual units, we may fulfil the purpose of the present article by discussing briefly a single system. In certain details, there are, to be sure, conspicuous differences from cluster to cluster; but in such matters as size, number of stars, and stellar make-up no great diversity appears.

The Great Cluster in Hercules (No. 13 in Messier's well-known compilation) is the system chosen for the present illustration. The right ascension of the cluster is 16h. 38m. 1, the declination is +36° 39′ and it is faintly visible, as a hazy star of magnitude 5.8, about two degrees south of Eta Herculis.

At the commencement of my studies on star clusters (*Mount Wilson Contributions*, Nos. 115-117, 126, 129, 133, 151-157, 160, 161, 175, 176, 190, 1915-1920; *Mount Wilson Communications*, Nos. 18, 19, 34, 37, 39, 44, 45, 47, 54, 62, 63, 64, 69, 1915-1920; and various papers in the *Publications of the Astronomical Society of the Pacific*, 1915-1920), Messier 13 was placed first on the list for detailed photometric examination because of its favorable position in the northern sky and because earlier work on the positions and spectra of its stars facilitated the interpretation of observational results. The large reflectors at Mount Wilson are well adapted to the study of rich clusters of this kind. A photograph of Messier 13 on a rapid plate with the 100-inch reflector shows the images of more than a thousand stars in less than a one-minute exposure. The photograph reproduced on facing page was made with the 60-inch reflector by Professor Ritchey, on a plate of medium rapidity, with an exposure of eleven hours; it records something like 30,000 stellar images brighter than the twenty-first magnitude. Nearly all of these are actual members of the cluster and not merely objects of the foreground, projected among the cluster stars.

The detailed photometric work on the stars in Messier 13, supplemented by the study of the distances of all globular clusters—a study which has involved investigations of Cepheid variables, red giant stars, stars of spectral type B, and the apparent diameters of clusters—lead to a definite determination of the position in space of the Hercules cluster. The parallax now adopted is 0″.00009, a value corresponding to a distance of a little more than 36,000 light-years.

Even to those who are accustomed to think of the great depths of sidereal space, it is difficult to comprehend clearly the remoteness of the Hercules cluster, notwithstanding that it is one of the very nearest of all the globular clusters whose radiation is continually streaming toward the earth. Its distance, 3.5 times 10^{17} kilometers, is more than eight thousand times that of the nearest star now known. Light, traveling with the hardly conceivable velocity of 300,000 kilometers in a second of time, requires eight minutes for the passage from the sun to the earth; but it must travel more than two thousand million times as long to reach us from this globular cluster. Hence our knowledge of the position and physical characteristics of Messier 13 does not refer to the system as it now exists. Our most recent information dates from the time the light we now receive left its remote origin in the cluster; and what has occurred there during the last 360 centuries is beyond our power of finding out. On the basis of our knowledge of the probable causes of these past conditions, we may believe with good reason that the cluster is at the present time much as it was 36,000 years ago. Such an interval of time is of small consequence in the life history of a gigantic stellar system; but while these pulses of light have been coming across the intervening fraction of unending space a thousand human generations have come and gone; man has emerged from a vague, unrecorded past and in fleeting succession all his historically known national civilizations have slowly evolved, flourished in vaunted permanence and supremacy, and quickly relapsed into oblivion or poor mediocrity.

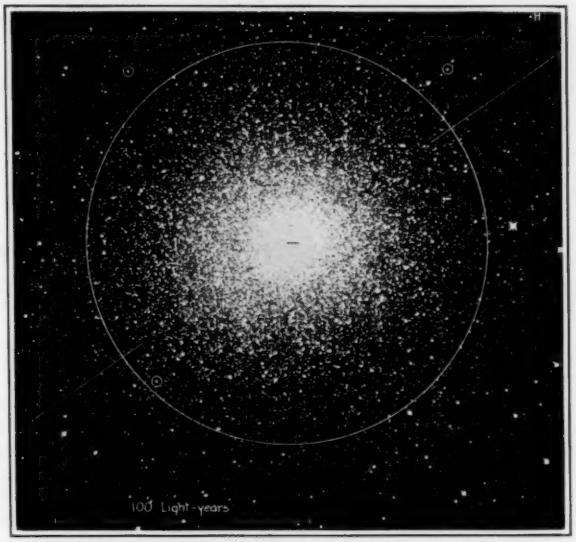
With the distance of the cluster known, we readily translate angular dimensions, as measured on the surface of the sky, into

linear dimensions. Thus, by the definition of parallax, the angular length 0".00009 corresponds in the Hercules cluster to the linear length of one astronomical unit—the distance separating sun and earth. By transferring a linear scale to the cluster, therefore, as in the accompanying illustration (which does not include the outlying stars), we may determine the separation of the individual stars, the number in a given volume, and numerous other facts concerning the physical structure of the system. It is worthy of emphasis that in determining the distance of the Hercules cluster we have at the same time derived the distances of its tens of thousands of stars.

A conception of the great size of a globular cluster may be gained by indicating on the picture of Messier 13 some of the familiar distances of the solar neighborhood. The distance separating the nearest known star from the sun (4 1/3 light-years for Alpha Centauri) is indicated by the short black line near the center. The distance from the sun to the Hyades, the well-known group of bright stars in Taurus, is represented on the photograph by the distance from the center of the cluster to the star marked H. The diameter of the large circle corresponds to ten million astronomical units; a sphere of that diameter, with the sun at the center, would include all the stars within eighty light-years of the sun.

The total angular diameter of the cluster is about thirty-five minutes of arc, corresponding to twenty-three million times the distance from earth to sun, or more than three hundred and fifty light-years.

All the cluster stars shown on the photograph are giants in actual luminosity, the most brilliant exceeding a thousand suns in light power. In apparent brightness, however, because of their great distance, few of them exceed the thirteenth magnitude. At the cluster's distance of 36,000 light-years, a star as bright as our sun would be considerably fainter than the twentieth magnitude—too faint to appear on this reproduction. The three cluster stars whose images are enclosed in small circles are photographically almost exactly one hundred times as bright as the sun.



ONE OF THE MEANS WHICH THE SKY HAS AFFORDED DR. SHAPELY FOR PURSUING THE PROBLEM OF THE SIZE AND STRUCTURE OF THE UNIVERSE

The globular cluster Messier 13, in Hercules. Its distance exceeds 200,000,000,000,000,000 miles and we see it by light that has been en route 360 centuries. It contains more than 36,000 stars that are brighter than our sun

Until recently the globular clusters have been accepted as spherical in shape. A systematic study of the photographs at Mount Wilson has shown, however, that a majority of globular clusters, as seen in the sky, are slightly but symmetrically elongated. This condition has been interpreted as a flattening of the cluster system—an indication that the clusters are not spheres but rather are oblate spheroids. Messier 13 is one of the most flattened; and though the elongation, in the direction indicated in the picture by inclined white lines, can be uncertainly seen visually or on photographs of the cluster, it is very readily shown by counts of the individual stars. There are about thirty per cent more stars in the direction of elongation than at right angles thereto.

The flattening suggests that this great stellar system may be in rotation about its shorter axis. Observations have not as yet determined whether or not such a motion exists. It is known, however, that the cluster as a whole is moving with a high velocity; and since the mass is probably in excess of 100,000 suns, we appreciate that the momentum of this moving cosmic unit must be exceedingly great. The only component of the motion now known, nearly two hundred miles a second, is directed toward the earth and toward the great extended strata of stars that constitute the galactic system. If the cluster continues to move with this velocity, it will have reached the galactic plane within fifty million years, coming from its present isolation in space to the regions where scattered galactic stars are numerous and where all the open clusters are found.

(To be continued)

DIFFERENTIATING THERAPEUTIC RAYS IN SUNLIGHT CURES

THE famous physician who has done so much to spread the doctrine of the therapeutic value of sunlight, Dr. E. Roux, recently made a valuable communication to the French Academy of Sciences, concerning the difference in effect of light rays and heat rays. His remarks which were presented at the Session of April 18, 1921, read as follows:

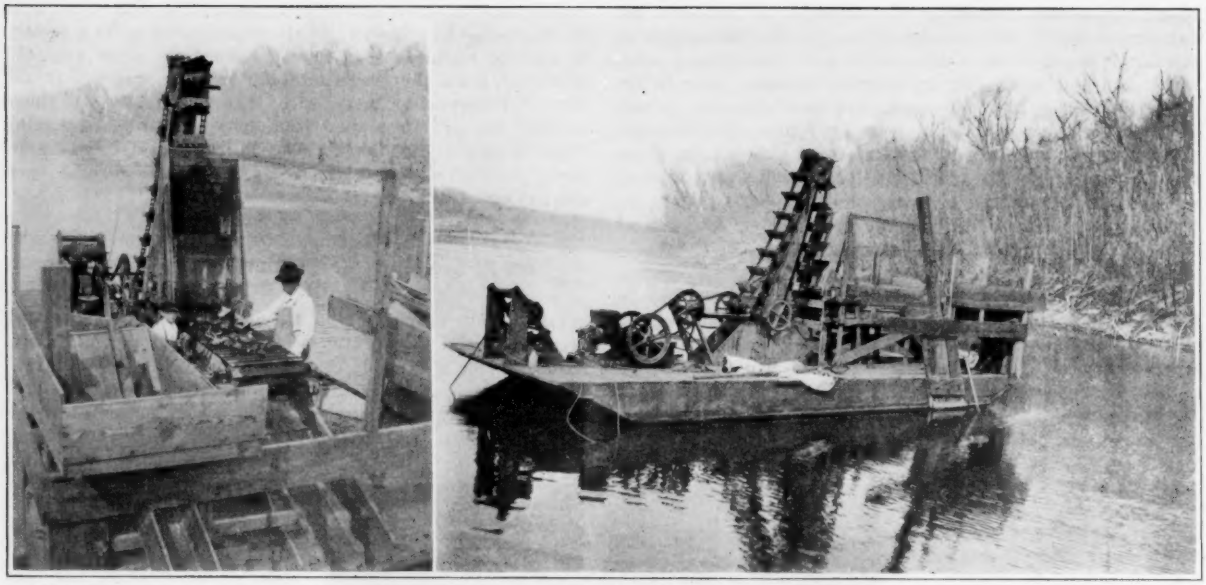
The exceptionally favorable conditions for the practice of helio-therapy which are presented by the atmosphere in the vicinity of Mt. Blanc and especially at St. Gervais, have enabled me to collect numerous series of data concerning the treatment by this natural curative agent of ordinary a-tonic wounds including varicose ulcers, burns, surgical wounds, etc.; as well as bacillary fisculas, tuberculosis of the ganglions, lupus, chronic arthritis of tuberculous or rheumatic nature, sciatic neuralgia, and other forms of neuralgia. Still another group of invalids treated by means of helio-therapy includes a certain number of persons suffering from chronic tuberculosis of the lungs.

While the admirable results obtained by helio-therapy are comparatively well known, it is less widely understood that the action of the solar radiations differs greatly according to whether they are hot or cold.

In the winter during the first hours of the day the solar radiations are cold and exclusively luminous. Between 12 M. and 2 P. M. these rays are accompanied by calorific rays. Thus an invalid exposed to the sunlight between 9 A. M. and 11 A. M. is acted upon almost entirely by light rays, while one exposed between noon and 2 P. M. is subjected to the action of both light and heat.

I was able to observe with great precision that invalids having closed tuberculous lesions (adenoids, adenites, arthrites and especially local lesions of the lungs) support the cold helio-therapy of the morning hours very well, but are incommoded by the warm helio-therapy of the afternoon, which occasions congestive coughs, a rise in temperature, perspiration, which is painful even when not actually dangerous because of the rapid evaporation. Rheumatic patients, on the contrary, as well as those suffering from arthritis, neuralgia, myalgia, suffer from the cold sunlight and derive the maximum of good effect from the combined action of heat and light.

It would seem, therefore, that the physician should make a definite distinction between the therapeutic value of light and that of heat, both as regards the choice of the locality selected for any given patient and of the best season for the treatment.



TWO PHASES OF THE MISSISSIPPI RIVER DREDGING INDUSTRY

Left: Dredging for shells on a tributary of the Mississippi. *Right*: Mechanical dredge of the type that is prohibited in some states. Where tolerated, these big fellows relieve the river bottom of anywhere from three to ten tons of shells in the course of a day

America's Fresh-Water Pearl-Button Industry

An Out-of-the-Way Commercial Activity and How It Is Carried On

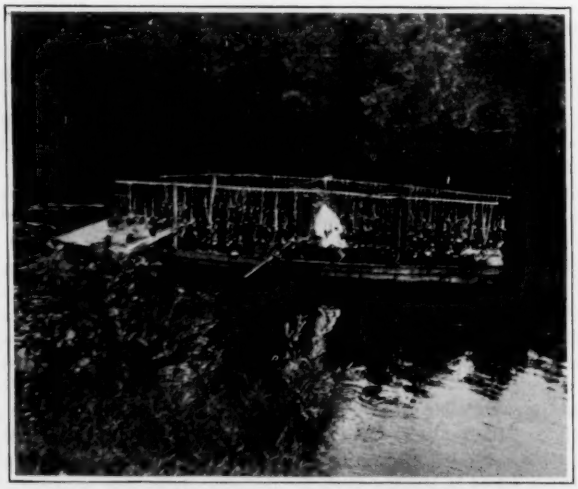
By S. G. Roberts

BUTTONING up America is something more than a practical necessity. Modern taste insists that this act should be performed with results for the most part pleasing to the eye.

There was a time when our citizenry of a less exacting period were generally satisfied with the modest china and humble bone button for many purposes; but nowadays the demand is for fasteners that shall be ornamental as well as useful—hence the ever-widening market for the lustrous pearl button.

Three decades back substantially all of the pearl buttons attached to American-made garments came from Germany and Austria, where their manufacture originated; but in the latter "eighties" chance led to the establishment of the business in the United States. At present our pearl-button factories, when operating to capacity, give employment to approximately 30,000 persons—many of whom are highly skilled craftsmen. It is rather suggestive that the domestic output of pearl buttons has reached a stage where we can ship them abroad, and during the year gone our exports of these articles had a total value of $712,714. They were sent to all parts of the globe, and we are, therefore, helping with pearl buttons to button up the whole world.

It is worth while recounting how we came to engage in the production of pearl buttons from native resources. Along about 1880 John F. Boepple landed on our shores and went to live in Muscatine, Iowa. Before leaving Europe he had learned the trade of making buttons from sea shells. Being fond of fishing he spent his leisure hours on the banks of the nearby Mississippi, and there happened upon some shells which he realized at once might be used for the manufacture of pearl buttons. He grasped, too, when he discovered mussel and clam shells in plenty that the regional fresh waters could be drawn upon for the nacreous materials essential to the craft in which he had qualified in the country of his birth. He visualized how an aquatic waste could be utilized in creating an industry of great promise.



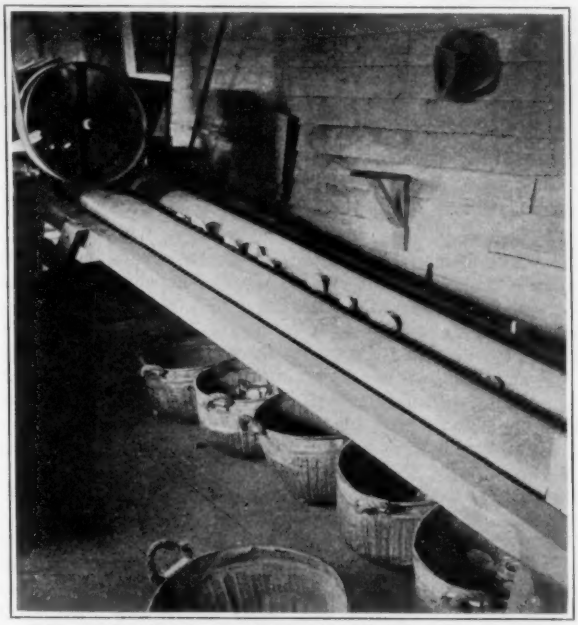
SHELL FISHERMAN, WITH TWO OF HIS DRAGS, AND THEIR STRINGS OF ATTACHED CROW-FEET SUPPORTED AT EACH SIDE OF THE BOAT

His next problem was to develop tools capable of cutting button blanks from the shells and then finishing these off into acceptable merchandise. Step by step he mastered the many difficulties, and his first button-making machine was a comparatively crude foot-driven lathe. However, with this modest equipment he fashioned acceptable pearl buttons, and was able to sell them as rapidly as he could turn them out. This recognition eventually won for him the needful support of capital; and from that rather unpromising beginning have evolved the twenty-odd plants now devoted to the manufacture of fresh-water pearl buttons in the United States.

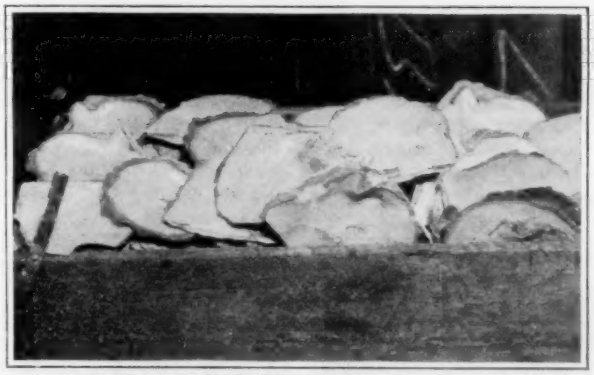
The factories are located in the States of New York, Iowa, New Jersey, Wisconsin, Minnesota, Indiana, Michigan, Illinois, Kansas, Arkansas, Ohio, West Virginia, Tennessee, Kentucky, Missouri, Oklahoma and Massachusetts. These establishments, exclusive of stocks of raw material and finished product on hand, represent a total investment of fully $4,000,000. According to the most recent figures available, the factories made 21,000,000 gross of buttons in 1914, and these were valued at nearly $4,900,000.

Since the inception of the native fresh-water pearl-button industry, machinery has been designed and built which is typically American in its capacity to do quickly and well the divers operations required in dealing with the shells and in transforming the blanks into beautifully finished buttons. But don't let us go too fast; in order that we may follow the evolution of the button we should start with the fishing for the bivalves which furnish the basic substance. These are mussels or clams of various sorts which abound notably in the Mississippi River and its numerous tributaries. Not all of them are fit for button-making, and the highest-priced commodities are manufactured from mussels commonly known as "mucket" and "niggerhead." The latter is especially valuable because it yields what the trade terms "iridescents."

The clammers or fishermen gather the mussels in two ways: by dredge, which is permitted only in some states, and by a drag consisting of an iron bar or pipe a number of feet long to which are attached by short lines numerous metal hooks. These hooks are four-pronged affairs of twisted wire and are popularly named "crow feet." The clammer drops his bar on to the water bed and draws it along over the area where the mussels are to be had. The movement is a slow one, and the bivalves, mistaking the hooks for morsels of food, close their shells upon them. They are slow to realize the nature of a crow foot, and the clam continues to cling for some time to it. Now and then, the fisherman raises his drag to the surface and collects the attached mussels, and this goes on until he has a boat load.



THE MECHANICAL CLASSIFICATION BY SIZE OF THE RAW SHELLS



A STACK OF RAW SHELLS READY FOR THE BUTTON FACTORY

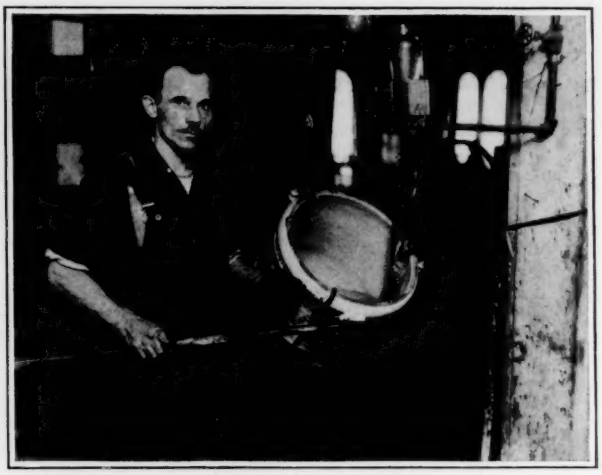
Harvesting clams or mussels for button making is just one phase of the fisherman's quest. Primarily, he is on the hunt for fresh-water pearls that are found of high quality in the bivalves which are plentiful throughout the drainage area of the Mississippi. Indeed, it is authoritatively stated that the incomes of the shell fishermen are derived from pearls and shells in the approximate ratio of one-third from the pearls and two-thirds from the shells. In a normal year the aggregate return amounts to something more than a million dollars. By reason of the double source of revenue, the clammer's first work after his bivalves are landed is to prepare them so that he can uncover any hidden gems.

For this purpose the mussels are steamed in a wooden vat built as a rule of two-inch planking a foot wide. These vats range from six to eight feet in length and in width from three to four feet, and have their bottoms protected by a sheathing of galvanized iron, the metal extending half way up the sides and one of the ends. The front of this structure slopes outward from the bottom to the top, and thus forms a ramp that facilitates raking out the mussels when they have been cooked long enough. It is customary to suspend a vat upon iron rods spanning a trench about two feet deep, three feet wide, and of the same length as the tank. Rising from the rear end of this excavation is a smoke pipe, and dirt is banked around this and the two sides. This leaves an opening at the front end where the fire under the tank can be tended. This makeshift cauldron is partly filled with water and then the bivalves are dumped in. As soon as the water has reached the boiling point the mussels open up, are taken out of the vat, and the gaping shells and the cooked meat are carefully examined for pearls. Both valuable pearls and baroques are frequently concealed in the bodies of the bivalves, and these may bring anywhere from 50 cents an ounce to as many dollars a grain. The discarded clam meat is often sold to neighboring farmers for hog feed. The shells have realized from $9.50 to as much as $55 per ton, depending, of course, upon the color, the luster, the size and the thickness of the raw material.

Inasmuch as a mussel bed may harbor bivalves of several varieties the shells from a catch are, therefore, of a correspondingly mixed character, and because of this the button maker, who buys his stock in miscellaneous lots, has to assort and to classify the shells after they reach his factory. From the various shells at his disposal he produces different sorts of buttons. To classify the shells he runs them through a machine which consists principally of two oppositely revolving rolls set slightly out of parallel. This leaves a tapering gap between them. As the shells feed downward along the inclined cylinders they drop through when the space permits, and, agreeably to their respective sizes, fall into the several receptacles arranged beneath. The shells so assorted are next put in soaking tanks where they remain for a week or more. The water renders them less brittle and makes their substance tougher in order that the shells can be cut into button "blanks" or discs without splintering.

The operatives that cut the blanks are specialists, each of whom has become skilled in handling a particular kind of shell and in getting the greatest number of blanks from every

AFTER THE BUTTONS ARE CUT, THEY ARE GROUND DOWN TO SIZE ON THIS MACHINE



A POLISHING AND GRINDING MACHINE THAT TURNS OUT 2000 GROSS OF BUTTONS A WEEK

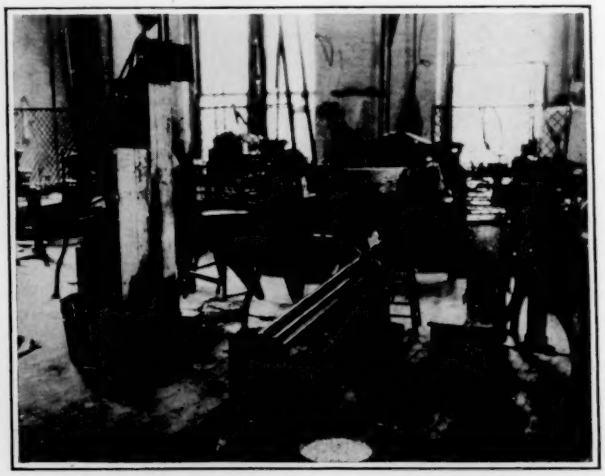
half of the bivalve's erstwhile cloak. The blanks are formed by tubular saws which are carried in a chuck of a lathe-like machine. One by one the blanks are shoved onward through the hollow of the saw and drop from the chuck into a bucket. All the while the saw is eating out discs from the shell the tool is sprayed with water to keep it cool and to drown any dust. The latter precaution is for the purpose of safeguarding the health of the workman. Otherwise the minute and sharp-edged particles might injure the eyes and seriously irritate the artisan's lungs.

The blank cutters are paid upon a grossage basis, and therefore, it is to their advantage to produce as many blanks in the course of a working day as possible. To utilize each shell as far as practicable these men cut out discs of divers diameters, and for that reason it is needful to assort the pailfuls of miscellaneous blanks. The blanks are classified according to diameter and thickness; and there are sorting machines which are able to separate at one time blanks of five dissimilar thicknesses. These apparatus are modifications of the double-roller affairs that first sized the raw shells. There is a further classification which groups the blanks agreeably to their quality. When the blanks have been duly sorted they are put in revolving drums, partly filled with water, where the hundreds of discs rub against one another and wear away their rough edges.

Up to this point the blanks still carry the unsightly "bark" of the outer surface of the original shell. This dark epidermis or coat is removed by revolving emery wheels in the grinding department, and the machines that do this work are built so that they can be adjusted to grind the blanks to any prescribed thickness. Once more the blanks are soaked, this time for three or four days. After that the embryo button is sufficiently softened to undergo the machining which rounds off the edges of the disc, scores out the characteristic depression in the middle of the face, and drills the holes in the center, two or more, depending upon the type or pattern.

American genius has devised automatic shaping and drilling machines each of which can produce in the course of a working day more than 150 gross of buttons. These apparatus are marvels of precision, and it is necessary that they should be. Drilling the holes or eyes is a very important operation in the making of pearl buttons, and if these were not spaced exactly the buttons could not be used in the button-sewing machines which are so extensively employed in certain branches of the garment industry. The shaping and drilling mechanisms have been so perfected that they do what formerly required three distinct hand machines. The blanks are fed to chucks, revolving under a sharp knife, which cuts the pattern. Next, the chuck carries the button along to a spindle in which is set the drill which bores the eyes. When these are finished the button is moved to the intake of an air-suction pipe, where the impulse lifts the button out of the chuck and drops it into a bucket underneath the apparatus. But the pearl button has not yet completed its evolution; it must still be subjected to

THE MACHINE FOR "FACING" THE BUTTONS



THE APPARATUS THAT DOES THE POLISHING

several treatments before it acquires that characteristic appearance which appeals to the ultimate possessor.

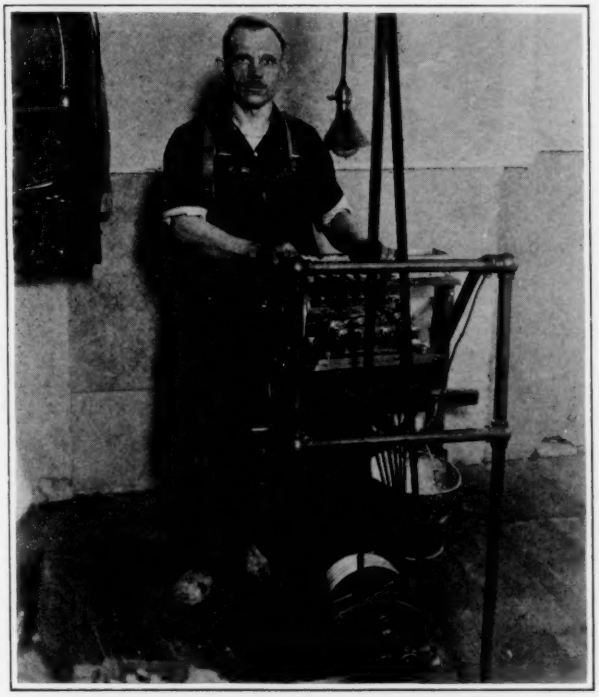
The shaped and duly drilled buttons are next sent to the polishing room. Upon the thoroughness with which this finishing work is done depends the pearly luster of the marketable buttons. First, the buttons are put in rotating metal churns where they rub against one another until their surfaces are smooth, and when this stage is reached they are shifted to polishing barrels, which also revolve, where they acquire the desired gloss. Attrition alone does not achieve the results. The smoothing churns are charged with a solution of sulfuric acid. This is weak at the start and gradually strengthened. At the end of an hour and a half the buttons are transferred to other churns where they are acted upon by hydrochloric acid for a couple of minutes. It is this acid that gives them their beautiful sheen. Having been washed with steam and water, the buttons are put in the polishing barrels which contain sawdust, and here agitation removes every trace of acid and the buttons are buffed by the woody material until they shine. This concludes the manufacturing process of the natural-colored pearl button.

Some pearl shells require bleaching, while the buttons made from others cannot be bleached, and these, by a special process, are tinted and become what are termed smoked pearl buttons. The present-day demand for buttons to match the hues of dress fabrics and the call for purely decorative buttons have led to the development of coloring methods. Aniline dyes are used for this purpose, and pearl buttons can now be tinted to harmonize with any shade of any textile. Buttons of this kind have an embellishing charm which is quite distinctive.

The work on buttons is not ended when they have received the finishing touches of the polishing barrels. It is indispensable that they be gone over and grouped according to their several grades before they are carded and boxed. It seems that some batches of buttons may be composed of as many as fifteen different grades, and their sorting is left to experienced, keen-eyed operatives who are alert and mindful of the slightest imperfection. Nimble-fingered girls are relied upon to do this. For the so-called cutting-up trade-manufacturers that turn out ready-made garments, the buttons are packed loose in pasteboard boxes, while for shipment abroad they are frequently put in cotton bags containing ten gross. For the jobber, however, the buttons are usually sewed on cards. This may be done either by hand or machine. The advantage of machine sewing is that it permits the removal of a button at a time without releasing the others on the card. For the sake of those interested, buttons differ in diameter, *i.e.*, size, by a measurement of lines, each line being one-fortieth of an inch.

As might be expected, the scrap shells from which the blanks have been cut would become an unprofitable waste if ways had not been devised to utilize the stuff. The shells are now extensively crushed and ground, and so treated they become an excellent poultry feed. The material serves the twofold end of grit and lime, the latter aiding in the formation of egg shells. The pearl-shell dust possesses properties which make it well worth while as a fertilizer; and this plant food has proved especially beneficial in the cultivation of alfalfa. Abroad, the meat of mussels, when dried and ground, has been discovered to be of notable value in the stimulation of egg production. Used for this purpose, the meat from the bivalves gathered by the pearl and pearl-shell fishermen would most likely render a greater profit as a chicken feed than as a food for hogs; this, of course, provided enough of the raw material were obtainable regularly to warrant the installation of the needful drying and grinding machinery.

The U. S. Bureau of Fisheries has given serious attention to the propagation of fresh-water bivalves suited to the manufacture of pearl-shell buttons. Eleven years ago the Government established a Biological station at Fairport, Iowa, where it carried on experiments in connection with fish that, at a certain stage, assist in the nurturing of the infant mussel. Other stations were subsequently instituted, and it is now known that mussels or clams can be propagated on a commercial scale and brought to a maturity fit for the requirements of the button maker in two or three years. Artificial propagation can be counted upon to improve the industry inasmuch as this procedure will render it practicable to promote the cultivation of the more valuable species of shells. There is no reason to fear that our manufacturers of buttons from fresh-water shells will ever lack a supply of the basic raw material.



DRILLING THE HOLES IN THE BUTTONS

Our fresh-water pearl factories have brought about a profound change in our domestic button business; and it has been declared that in the course of two decades buttons from the clams and mussels of our inland rivers have saved Americans the tidy sum of fully two hundred million dollars, and all because buttons made from pearl shells of oceanic origin are more expensive. But the industry represents something else of economic importance: it has shown us how we could utilize forms of aquatic life that previously were well-nigh totally neglected.

But let us not lull ourselves into the belief that this comparatively new field of activity is secure for the future because of the mere fact that we have created effective special machinery and that our river beds can yield us an abundance of suitable bivalves. We must bear in mind that labor charges constitute the biggest single item in the cost of turning out an acceptable pearl button. The Japanese are rapidly adopting our mechanical methods and duplicating American apparatus, and they are able to obtain skilled workers for a daily pittance that is only a trifle of what we have to pay here for the corresponding laborer or craftsman. This situation is one that calls for serious consideration on the part of our tariff experts. Domestic enterprise has enabled us to hold our own against the competing button makers of Europe, and we have benefited. It is equally essential that this typically native line of endeavor be protected against the menace of low-priced labor of the Orient.

Between the Infinites

An Essay Upon the Impressive Magnitudes Which the Universe Presents

By Hudson Maxim

THE way of life is along a narrow ledge between the infinitely great and the infinitely little. Topless heights tower above and bottomless depths yawn below. We have forgotten whence we came, and mists of uncertainty shut out our view of the beyond. Belief in our own size and importance depends upon the narrowness of our horizon, for just in proportion as we become aware of the immeasurability by which we are surrounded do we become conscious of our very littleness.

The savage who sees earth and heaven meet at a distance of only a few miles imagines that his inverted bowl of sky covers the universe — that fortunately he is situate in the very center of it; and he may well swell and strut with self-importance. But when he climbs a high mountain, and finds the land stretching away, an eye's mighty reach, before it joins the sky, he is forced to readjust his opinion of the size of the world. It is bigger than he thought, and a question is born in his mind that possibly, could he mount still higher, the horizon would again be greatened. Similarly, the scientist, climbing the heights of knowledge, finds that he must constantly readjust his opinion of the size of the world and of the universe to accord with his changing points of view.

Impelled by his powerful passions, appetites and needs, man, through the ages, has been grappling with the forces of nature to understand and conquer them to his use. The desire to investigate and fathom natural phenomena — a desire grown with us through the ages — the desire to go with the imagination into the great heights and depths of things and bring back knowledge from the remotest shores of the knowable, has now become a passion. The advance of cold, calculating science need not make us fear for the old wonder-world whence we are emerging, as a playground of the imagination; for even today the magic wand of old Mystery halts gray-haired Science confounded on the brink of the unknowable, and he reaches to take hands with his mystic brother, while together they peer into the depths where are new and greater wonder-worlds. The wonder-science which we inherit from the long ages is stronger with us than the new-born science of reason. Modern science is a parvenu.

All pleasure is due to the exercise of faculty; hence when any faculty is exercised in an unusual degree, but in a less degree than will injure the faculty, the exercise serves as a tonic. We are exhilarated by looking from a great height upon surrounding landscape, because the faculties brought into play are doing unusual duty. Similarly, anything which gives us a new or deeper view of the mystery of things exhilarates us through the imagination. The keenest delights of the scientist and philosopher arise from the contemplation of stupendous magnitudes, or of littleness that transcends understanding, and in trying to fathom the depths of environing mystery where science has not yet penetrated. Sublimity in poetry, power of oratory, and much of the force of every-day utterance depend upon the use of potential words and forms of expression which stimulate perception of magnitudes. Eliminate from Milton's "Paradise Lost" all that stimulates by the contemplation of magnitudes and it would be without sublimity.

To Herbert Spencer the thought of endless space was an obsession. That space is endless is an awful thought. That space has an end is inconceivable and we are certain that there is no end. Similarly, we are certain that time is without beginning and without end.

Though encompassed on all sides by infinitude, by a vastness which we cannot now understand, and may never hope to understand, still there are many truths of which we may be as absolutely certain as of our existence. For example, the laws of physics. Assured of these fundamental truths, possessed of this primary knowledge, man, though but an infinite mite on an infinitely little world — a mere point relatively of inconceivable minuteness in immensity — is able to understand the ways of the stars that shine on him from the bottomless deeps of infinitude, able to weigh suns a thousand times as great as his own and a million times as far away, and to discover their chemical nature from analysis of their light — light which left them before the Egyptian pyramids were builded, or China had a history. He can tell us the temperature of Sirius as compared with that of Arcturus, using an instrument so delicate that it will measure the heat of a candle-flame nine miles away. Man has made an open book of the geologic strata of the earth, and has unraveled his own history and traced his pedigree back through the descending stages of animal life down to the moneron, a speck of protoplasm born in the azoic sea. Man has penetrated the future, not with prophecy, but with fore-knowledge that sees our sun burnt out and the earth dead in the sepulcher of time; and beyond that death, man believes he knows that, far down the ages, an inconceivable and to us practically endless time, a new solar system shall be born of ours in some great stellar collision, where a new earth among new satellites may be peopled by another human race.

All celestial processions are in cycles. Hence, it is not only possible, but probable, that somewhere in the universe today there are other worlds similar to our own, with similar beings upon them. We have only to realize that space is endless to appreciate that there is plenty of room; have only to realize that time is endless, to appreciate that there is plenty of time, and that forces are infinite for infinite possibilities.

Our conceptions of the great and the small are only relative. When a twelve-inch cannon, charged with smokeless gunpowder, is fired, the time that elapses between the flash of ignition and the instant the projectile leaves the muzzle of the gun is about the sixtieth of a second, a period so brief that to our sense it appears instantaneous.

Sixty such cannon could be arranged side by side and discharged by electricity, one after the other, within the time of a single tick of grandfather's clock.

Some weeks ago the senior member of our staff and the Einstein Editor were discussing with Hudson Maxim certain aspects of the relativity theories, when the inventor produced from his files an essay which he had written several years ago for an almost forgotten paper of very short life, the Times Magazine, but which he had never put into a place where it would be generally available. Many people have written with more or less understanding and literary skill upon the appealing subject of the infinite; but Mr. Maxim's essay appeared so far and away the best thing of the sort we had ever seen that we took it right away from him for publication in our columns. It is seldom indeed that in the more or less hum-drum procedure of chronicling scientific and mechanical progress we have the opportunity to present a piece of literature of such high order as this.—THE EDITOR.

The rate at which smokeless powder burns in a gun, under the high pressure, is about the sixtieth of an inch in the sixtieth of a second, or about four inches per second, and this we call slow-burning in smokeless-gunpowder parlance. The rate of combustion of high explosives, such as dynamite, is much higher, being about four miles a second. The pressure exerted by Maximite, nitro-gelatin, nitroglycerin, picric acid, and other of the most powerful high explosives at the instant of detonation, is estimated to be between three hundred thousand and five hundred thousand pounds to the square inch.

Great as is this enormous pressure, and great as is the speed of the detonative wave, we have, in studying the structure of the universe, to consider forces which make these seem insignificant.

We frequently hear the theory advanced that planets and suns explode; and that our own earth might possibly explode from pent-up forces within. A high explosive exerts about the limit of pressure capable of being exerted by gases set free and expanded by the heat generated by any chemical reaction. Such a pressure, great as it is, is far too insignificant to explode this earth. Were the whole great molten interior of our globe to be replaced by dynamite and detonated, the explosion would not lift the earth's crust. We have but to calculate the weight of a column of granite of a height equal to the thickness of the crust of the earth, to see that the pressure of the crust on the molten interior far exceeds the pressure exerted by exploding dynamite. We have seen that the speed of the detonative wave is about four miles per second. The speed of the earth in its orbit is four times as great. If therefore, the interplanetary space of our solar system were to be filled with an explosive mixture capable of being detonated and consumed with the speed of dynamite, and if this were to be set off just behind the earth in its orbit, the earth would not feel it, but would rapidly rush away from the wave of explosion, pass clear around the sun, and come back again to meet it more than six months later. It would take nearly a year for such a detonative wave to reach our sun from the earth. If the earth itself were a ball of dynamite, it would require half an hour to explode; and if the sun were a mass of dynamite, it would require about two and a half days to explode.

The flight of the earth in its orbit is very slow, however, compared with the speed of many other heavenly bodies. Meteorites frequently have a velocity of fifty miles a second. A sun moving at a speed of from four to five million miles a day is not thought by astronomers to be exceeding the speed-limit. One sun is known to be moving at about seventeen million miles a day. Suns moving at the rate of four to five million miles a day, though but a moderate distance away compared with other stars, are still so remote that since the foundation of Babylon they have not moved along the sky an apparent distance greater than the diameter of our moon. A celestial body moving at an average rate of five million miles a day would require more than eighteen days to reach the sun from the earth, a distance of ninety-five million miles. Yet light is so much more rapid in its flight that it traverses that space in about eight minutes. We have seen how slow are the operations involved in the discharge of a cannon, which, though to us apparently instantaneous, are slow compared with the vastly more rapid explosion of dynamite; and again, how slowly moves the detonative wave when, in its turn, it is compared with the velocity of the heavenly bodies. Now we find that even these amazing velocities are a snail's pace compared with the speed of light.

If we could but borrow the wings of light and sail through the universe, what voyages of discovery we could make! But stay—let us do a little figuring. How far could we go and what stars could we visit and return from in our short lifetime? The distance to our sun is sixteen thousand six hundred times the diameter of our earth. Taking this distance which separates the earth from the sun as unity, for a celestial yard-stick, the nearest fixed star, Alpha Centauri, is two hundred and seventy-five thousand times that unit. This is our nearest solar neighbor, and our next nearest neighbor, 61 Cygni, is almost twice as far again—nearly five hundred thousand times our celestial yard-stick. If we conceive an enormous hollow sphere, with our sun in the center, it would require a diameter of nearly a million times the distance to our sun to enclose 61 Cygni. There would be only two stars besides our own in this enormous void. It would take us, moving with the speed of light, more than four years to reach our nearest neighbor, Alpha Centauri, and almost twice as long to reach our next neighbor, 61 Cygni. It would require thirty-four years to reach Arcturus; a lifetime of threescore years and ten to visit Arcturus and return.

Remote as are these stars in the depths of infinitude, they are relatively our next-door neighbors in comparison with the great mass of suns lying beyond, whose numbers are known to be more than a hundred millions. Some of them, whose lights are too dim to be seen through the most powerful telescope, are revealed to us by the photographic plate. It has been estimated that the faint rays reaching us from some of these stars left there fifty thousand years ago—thousands of years before Niagara had begun to cut its gorge. What mites we are! Yet it is a consolation to know that the warmth of the cheek of our fair lady and the reflected light from her beautiful eyes are felt in Arcturus; or rather, will be felt in Arcturus thirty-four years hence. The light she places "in the window for thee" pierces not only our little night, but goes on forever through the night of immensity, eddying around dead old suns lost in infinitude. When a fly lights upon your hand, the whole earth moves to meet it a distance exactly proportionate to the fly's mass.

Again, considering ourselves introspectively, it is a consolation to know we are so wonderfully constituted that no image of any object which has rested upon the retina of our eyes is ever wholly effaced from memory, either conscious or subconscious. No sound is ever completely obliterated—no thought but lives as long as we live. Thoughts, images, and impressions, though far beyond recall by the conscious mind, and individually too faint to exert a material influence upon us, still, in the aggregate, with many millions of other and similar impressions, go to make up that ponderable subconscious experience which underlies our character.

Meteoric dust glows upon us from a vastly distant nebula; and the light of an individual particle of that nebula, though utterly imperceptible, and all but utterly lost, still contributes its individual part which, combined with the billions of others, reveals its presence to us.

Just as one person's memory exceeds that of another, so does one person often far exceed another in his powers to recall into consciousness and to utilize his subconscious powers. Such persons are said to have powerful imaginations. The imagination is the playground of reason; and when we set our fancy free and follow her leading, we penetrate immensity with a pace that makes even light a slow-coach.

Had we eyes of infinite powers, and could we fly outward through space at a sufficiently high rate of speed, we should overtake the rays of reflected light which left our earth thousands of years ago, and as we went we could look back and behold the history of our earth unravel, see the return of man to the ape-like thing, see him and all animate forms finally converge upon the moneron plunged in the azoic sea. The effect would be similar to that of the cinematograph, when a course of events is reversed upon the screen by running the tape backward, which makes the divers who have plunged from a height into the water seem to plunge up backward, heels first, upon the platform from which they descended. It is an extraordinary fact—nevertheless a fact—that the reflections of all these antediluvian saurians who lived in the earth's infancy are still moving onward somewhere in immensity, and could we be there, with infinite eyes, we could still see them plunging about in the ancient ooze. Strangely intermingled are the infinitely great and the infinitely little.

We have already remarked the dependence of sublimity in poetry and the power in oratory upon the potential words and forms of expression which stimulate the imagination through the contemplation of magnitudes. Let us, for convenience' sake, picture ourselves taking flight from our infant planet to make a voyage of discovery through infinitude, restricted in our speed only by the necessity of threading our way among the stars, and we have an opportunity for about the limit of the possible in picturing and contemplating vast magnitudes of time, space, power, and mass.

Could we actually travel at the speed of thought, that is to say, could we reach any star on the instant of thinking of it, our speed would be limited only by the time required to think of one star after another in their order, thinking first of the stars lying nearest in the line of flight, to avoid colliding with any of them, which would occur if we first thought of a star lying just behind another.

Could we go out through the spangled universe with such inconceivable velocity as this, the fixed stars on either side would appear to rush by us with such velocity as to leave streaks of light upon the surrounding dark, while the stars lying directly in front of us would appear to burst from the dark and to disappear with the rapidity of a flash of lightning. The effect would be similar to a great flash of sheet-lightning at night on the face of a black storm-cloud.

Celestial dynamics present some strange paradoxes. We have learned that the condensation of a nebula evolves heat, that is to say, the more the nebula condenses, the hotter it gets. This heat is being continually radiated into space, causing still more condensation with the evolution of still more heat. In other words, the more a nebula is cooled off, the hotter it gets, until we have a solar system with an incandescent sun in the center, with planets revolving round it which broke away from the rotating mass during the process of shrinking. The planets are at first incandescent, but being smaller than the central mass, lose their heat more quickly, the smallest planets losing their heat first. The sun still goes on cooling and shrinking and still growing hotter and radiating heat into space until it passes the critical point when it changes from a gas to a liquid, when no further heat is produced by further shrinkage. Then the sun going on cooling, passes from the liquid to the solid, from incandescence to red heat, and from red heat to blackness and death. The enormous black mass sweeps on through the infinite night, with a velocity so tremendous that when it encounters, which it is sometime certain to do, another celestial body of nearly its mass, or exceeding it in mass, and moving at a similar velocity, sufficient heat is generated by the impact to convert both participants in the collision into a mass of incandescent gas so inconceivably hot that it is quickly expanded far out into space, and when expansion has ceased, the work required to propel all the particles of the mass outward to the positions they then occupy is exactly equal to the energy developed by the collision. We have again a nebula and it is infinitely cold, but not quite as cold as outer space; hence condensation begins again—a new creation begins.

It is frequently necessary for the artist to put a man or other animal whose size is familiar, into a picture, in order to enable us to appreciate the size of other objects. In like manner, we are better enabled to grasp stupendous magnitudes by drawing comparisons between magnitudes which we can easily comprehend.

We have spoken of the distance between the earth and the sun as our celestial yard-stick. If we were to represent the universe on such a small scale that our celestial yard-stick would actually be but three feet, a small marble a third of an inch in diameter would serve to represent the sun. The earth would be represented by a small speck one-three-hundredth of an inch in diameter, just visible to the naked eye, at a distance of three feet, while Neptune, our frontier planet, would be represented by another small speck one-eightieth of an inch in diameter at a distance of ninety-eight feet. This would represent our solar system in miniature. And if this miniature solar system were laid out on the smooth cement pavement in front of the City Hall, New York, and we wished to add the nearest fixed star, the double sun Alpha Centauri, it would be represented by two small marbles one hundred and seventy miles distant—for instance, Baltimore, Maryland, while the next nearest fixed star, the double sun 61 Cygni, would be represented by two small marbles placed more than three hundred miles away, or, for example, at Augusta, Maine.

If a twelve-inch gun were to be fired from the earth at Alpha Centauri, and its projectile were to travel to that star at an uninterrupted velocity of twenty-two hundred feet per second, the flash of the gun would be seen there about four years after it was fired, and the sound would reach there nearly four million years later. The projectile, traveling about twice as fast as sound, would reach there in nearly two million years after the flash was seen.

We are unable to comprehend such magnitudes, consequently vastly smaller magnitudes may appal us in an equal degree. For example, the coal in the State of Pennsylvania would, it is estimated, supply the whole United States at the present rate of consumption, for a thousand years. This immense mass of carbon, if precipitated into the sun and burned, would supply its radiant heat for only the thousandth of a second. Again, it would take a row of Niagaras circling the earth three times, with every foot-pound of energy utilized in electrical horsepower, to equal the energy which the earth receives from the sun. In other words, the work which the sun performs upon the surface of the earth, is equal to that which would be required to pump from the ocean water enough to supply a Niagara seventy-five thousand miles wide.

Here is a question with which we may interest and puzzle ourselves to the heart's content, or discontent. We believe, as has been stated, that all celestial processions are in cycles, and behind this belief we have the knowledge that the amount of matter in the universe is a constant, and that the total amount of energy in the universe also remains constant, all changes being due to changes of the relative positions of atoms of matter giving different manifestations of force, all matter being one in the ultimate. We know, further, that there can be no effect without a cause, and that there are no more effects in the universe than are exactly due to producing causes, which causes are due to and are the effects of preceding causes, while all present effects are the causes of effects to come.

Now, therefore, we know that if all the atoms in the universe were to be placed back again in exactly the same positions with respect to one another which they occupied a thousand years ago, possessing the same movement they then possessed, all the atoms would, after the lapse of a thousand years, be exactly where they are today. Consequently, every human event would reoccur exactly as it has occurred during the last thousand years, and we should all again be here and actuated by the same inertia of purpose which impels us to work out our destinies without changing the nature of a single atom or swerving one from its destined course.

The vibrations of the atoms in the minute molecule are governed by the same exactitude as the march of suns. The flight of a comet and its return from the sidereal depths may be calculated and foretold to a day. The solar eclipse is predicted to a second. If we now extend our thousand years until it embraces eternity, what must we conclude? Let us follow the cycles of the suns. Nebulæ are born in the crash of worlds; nebulæ become suns, and these in turn give birth to planets, and planets evolve animal life up to man. Planets grow old, their suns wither and grow cold in the dark sky, where they wander on to a predestined collision with other, and perhaps dead old spheres, coming to meet them out of the great darkness. Then new nebulæ, new suns, new planets, and new men shall come again. Though the time be long, it counts for nothing in eternity. The life of a sun is relatively less in infinite time than the duration of the flash of an evening

fire-fly compared with the life of our sun. Is this appalling thought true then, and we know of no reason why it is not true, that races of mankind have occurred in all past time, and will reoccur during eternity? Their occurrences, therefore, must be infinite in number, and although but an infinitely small portion of the ponderable matter in any solar system ever actually takes human shape, still it requires only time long enough in order that every atom in existence shall pass through the human heart, as it must in the nature of things have heretofore passed. In short, it requires only time enough for it to have passed through the human heart an infinite number of times.

If the cards be shuffled times enough, we may all draw a royal flush, so it is but necessary for the infinite to shuffle the stars times enough to give every atom in existence the royal chance of mounting through the human frame to the dignity of brain, and throne of thought, mind, soul.

ANIMAL BEHAVIOR AS A FACTOR IN THE FORMATION OF BONE BEDS

THE occurrence of fossil vertebrates massed together in considerable numbers in restricted areas is a familiar fact to experienced collectors. These aggregations are usually spoken of as bone beds or quarries by collectors of fossils. Various theories have been proposed to account for the surprising abundance of vertebrate remains in certain quarries and their absence or scarcity outside these limited areas. Different kinds of bone beds evidently require different explanations.

In the case of bone beds in which only a single species or closely associated species are present, the accumulation of the remains of numerous individuals may be explained by the peculiar behavior of some animals of the present time on the approach of death from starvation or freezing. Such bone beds appear to be common in the Cretaceous. Mr. C. M. Sternberg is acquainted with "no less than 7 bone beds in which only horned dinosaurs are represented."

Darwin has described the curious instinct of the guanaco of South America which leads it to "have favorite spots for lying down to die. On the banks of the St. Cruz in certain circumscribed spaces which were generally bushy and all near the river the ground was actually white with bones."

A western correspondent, Mr. R. A. Brooks, has given me in a letter a description of the behavior of cattle and buffalo on the western plains under the stress of cold, starvation and fright, which clearly indicates how large masses of the bones of these animals have been accumulated. Mr. Brooks states that: "During the hard winter of 1906-07 thousands of head of cattle perished from starvation and cold. I remember well how some of them died. The first cow to die usually felt it coming and left the bunch or herd and slowly made its way to a lonely place, generally a clump of brush or a coulée, and lying down simply waited to die. The next one feeling her time approaching followed in the tracks of the first one, and died close beside her and this was kept up until there were no more, or relief came. At the U Ranch in the Hands-Hills, central Alberta, the owner showed me a coulée where 450 head of his cattle died. This pile of bones actually made a dam across the ravine. Within half a mile was another pile of bones, all that was left of 675 head. Everyone acted the same way. The owners told me that hardly half a dozen died separately and these were on their way to the dying place.

"There is also another place on the Beaver Dam River where countless buffalo died of thirst during a dry year. An old Indian told me that long ago there had been nearly three years of rainless seasons. All the rivers were dry as well as most of the springs. But one kept flowing very freely on the banks of the Beaver Dam. When a herd of buffalo would come near enough to scent this, there was a stampede for it and the ones behind would literally climb over the front ones and trample each other to death. Prairie fires also were the cause of many buffalo bones at the bottom of cliffs, and it is well known here that in the early days the Indians themselves used to stampede herds of buffalo over the cliffs."

This account of the behavior of western cattle under the conditions described, and the mass destruction of the buffalo when acting under stampede excitement, gives an insight into phases of animal behavior which may have been a factor in the formation of some fossil bone beds. It may be that the Alberta dinosaurs of Cretaceous times when famine came, like the Alberta cattle of today, sought a common dying ground.—E. M. Kindle, in *The Canadian Field-Naturalist.*

NEW POINTS ABOUT PIGMIES

IN various parts of Asia and Africa there are found those curious dwarflike races known to anthropologists as pigmies. They inhabit almost exclusively regions lying on the borders of those zones inhabited by other races of men—regions which are either waterless steppes such as those occupied by the bush folk in South Africa, the Kalahari, or else dense primeval forests such as the forest dwarfs of Central Africa, the Andamanese along the Bay of Bengal, and the Negritoes of the Philippine Islands. It is not possible to draw a sharp line of distinction between these races and the rest of mankind since the varying degrees found in the size of the body forms a connection between them and the taller races living near them. These intermediates, however, appear to be the result of racial crossings. Thus, the Senoi and the Semang upon the Malay Peninsula and the Taola of the Celebes Islands, can hardly be regarded as pigmies, though they are undoubtedly closely related to the Andamanese and the Negritoes; they are hybrids between an original pigmy population and later adventurers, and there are constantly found among them individuals who resemble more or less closely other primitive races. Upon the island of New Guinea also the blood of the original pigmies has been mingled with that of the Melanesians who made their appearance later.

The Negritoes of the Philippines are the pigmies which have longest been known to Europeans since the Spaniards came across them in very early times. Before the immigration of the Malays they appear to have occupied the entire group of islands, although today they have been driven to find retreat in remote mountainous forests; they are most abundant at the present time in Northern Luzon, but small remnants of them are to be found on almost all the islands of the Philippine group. They number about 23,000, whereas the Andamanese have been reduced to a population of 2000.

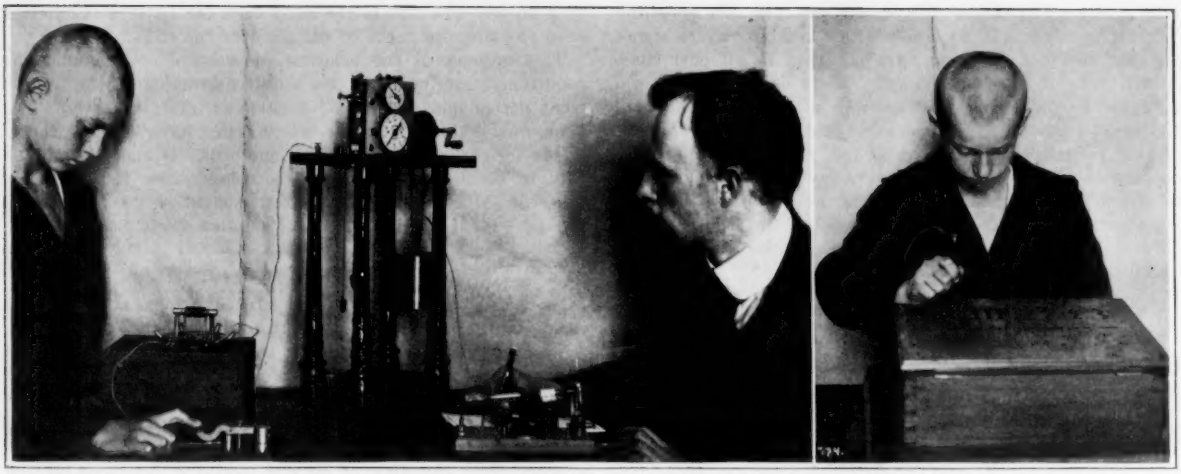
Among the African pigmies the bush folk or forest folk have been almost entirely exterminated, while the dwarfs of the primeval forests from the Cameroon as far as the East African seashore are still pretty numerous and well distributed, for the reason that the dense forest shelters them against both negro tribes and European explorers and settlers.

Thus far the shortest heights found in any grown man are as follows: Negrito, 128; Andamanese, 138; Kung, bush folk, 142; Hei'kum, bush folk, 149; Babinga, 140 cm.

The proportions of the body bear a close relation to the stature in pigmies, especially as regards the great length of the trunk compared to that of the legs. A connection is very generally found between a low stature and childish proportions.

Besides their small size pigmies are distinguished by various other marks, such as the delicacy of the hands and feet, the childish form of the forehead, the convex upper lip and the short, broad ear without a lobe or with a grown-on lobe. . . . The color varies among different tribes, being sometimes a light brown like that of a dead leaf, sometimes rusty black as in the case of the Negritoes, dark brown as in the Andamanese, or even pale reddish yellow as in some of the forest pigmies.

While some authorities have held that pigmies are the result of retrogression in higher races, the best modern view seems to be that this is a mistake and that they are merely admirably adapted to the conditions under which they are forced to exist. They are believed to be older than the taller peoples which live in their vicinity.



MUSCULAR PRECISION AND CONTROL ARE MEASURED BY THESE SIMPLE TESTS

Left: The subject strikes a telegraph key repeatedly, and the instrument registers the degree of success which he attains in his effort to give the same force and the same duration to all strokes. *Right*: In this test for quickness of eye, the plug must be inserted into the hole without striking the rim, else a circuit is made and a bell rung

Psychological Tests of Industrial Capacities

The Methods Employed Here and Abroad for Divorcing Square Pegs from Round Holes

By May Tevis

IN the Middle Ages—the golden age of craftsmanship—when every artist prided himself upon being a skilled artisan and when it was the ambition of every gifted 'prentice to become not only a good artisan but to continue his studies till he might claim the proud title of artist, earnest consideration was given by parents and guardians as to the choice of the most suitable craft in which to launch their young charges. Even among many primitive peoples it is said to be the custom to place various objects of symbolic character, such as an apple, a young animal, and a bow and arrow near a young infant, with the purpose of observing which of these most engaged its attention, so that they might be guided as to his fitness to become a husbandman, a shepherd, or a huntsman.

But the tremendous upheaval brought about during the last two or three centuries in the arts of industry by the rapid development of machinery and its accompanying handmaidens, steam and electricity, occasioned an almost entire breakdown of the old system of guilds with their master craftsman, their journeyman workmen and their apprentices. In their stead we have seen the rise, at first very gradual and more recently very rapid, of the trade unions. These bodies of labor, organized originally for mutual benefit, self-protection, and legitimate collective bargaining, but of late constituting, in the opinion of many observers, as serious a menace to the rights of the public as are the profiteering capitalists at the other end of the scale, have incidentally largely contributed to the decay of the system of apprenticeship, through mistaken jealousies and fears.

These circumstances, combined with various other factors, have led, especially during the last fifty years or so, to great uncertainty and confusion in the minds of youths casting about for some avenue to employ their energies at the outset of their industrial lives. As a consequence there has been an enormous waste of energy through the presence "of round pegs in square holes" and these industrial misfits have not only reduced the earning power of the individual, but have been the source of an enormous amount of economic waste, resulting partly from the lowered yield in units of work and partly from a heavy increase in the expensive item called turnover in factories and business houses.

But at last science has begun to find a remedy for this in the application of experimental psychology to the study of men and women, and particularly of boys and girls for the purpose of discovering the peculiar aptitudes and deficiencies inherent in the individual.

One of the pioneers in this subject was the late Professor Hugo Münsterberg of Harvard University, whose greatest service, perhaps, was the calling of popular attention to the subject, an attention not unmixed with ridicule from the groundlings. Indeed, though the whole subject has made enormous strides in public appreciation, there are still a good many people who profess the methods of the psychologists considerably far-fetched—a fact attested, by the way, by the recent appearance in one of our most popular weekly magazines of a farcical tale written for the express purpose of deriding the operations of an "efficiency expert" called in by the head of a big business to make psychological tests of his personnel, with the result that the cashier was set to run the elevator because of his mechanical thumb, and the elevator man put in the cashier's cage because of his mathematical ear. It is because of such misapprehensions as this that it seems worth while to give a plain statement of some of the methods actually employed for testing applicants both in this country and abroad. That the matter is far from being all moonshine is attested by the fact that many of the most important industrial companies all over the world hire no men without testing them both for their general fitness and (in the case of apprentices and beginners) for their specific suitability to receive their training in one or another line, *e.g.*, as a turner, a designer, a carpenter.

In America, and we believe the same thing is true elsewhere, an especial impetus was given to the matter by the necessity of placing the thousands of men recruited by the army in positions so far as possible where their natural abilities and special training might produce the best results. Here the psychologists came into their own, and were of immense help to the military authorities, in spite of the fact that they were facetiously known among the men as "the nut-pickers." The army tests are too well known to be repeated here, however, and we shall confine ourselves to the somewhat different methods employed for investigating the aptitude of would-be employes. These fall

into two general classes, one consisting of written tests or group tests, as they are sometimes called, and the other of individual tests with or without apparatus. In the first class it is the mental ability which is of most importance, while in the second it is the acuteness of the senses, the coordination of the muscles and the power of the will which count most.

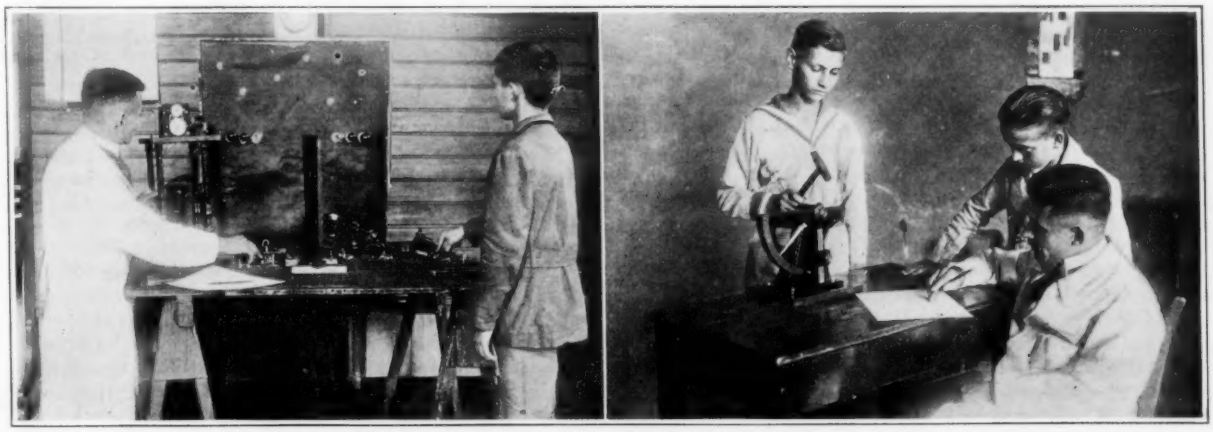
The mental faculties which are of basic import are the power of attention of memory, of imagination, of judgment, of reasoning, and a capacity for making observations. Attention may be instantaneous or concentrated for a longer period of time and both faculties are advantageous. A common test of the capacity for concentrated attention during a given lapse of time consists in giving the subject a printed text in which he is required to strike out certain letters—"a, e, and n" for example. Some subjects are able to do this very rapidly while others are very slow about it, but it must not be thought that the latter case is always due to stupidity, since it may, on the contrary, be caused by a greater degree of conscientiousness. Again, one applicant may work very fast, but be guilty of a number of mistakes, while his slower comrade makes very few or none at all. Another point brought out by the experiment is that some applicants have their errors pretty evenly distributed while others show a marked decrease in correct judgment toward the end of the test.

There are various methods, of course, for testing the memory and here, too, there are differences shown since some subjects commit to memory readily but forget promptly, whereas others are slow to learn but display very retentive memories. Occasionally, there is the supposedly ideal memory which is "wax to receive and marble to retain." A common method of testing the memory is to place the same text before the entire group who are undergoing an examination, with the requirement that it be "learned by heart," and later reproduced from memory either precisely or as regards its main points. An accurate and retentive memory is considered especially desirable in the learned professions such as law, medicine, and teaching. The present writer is of opinion, however, that in some cases a too facile memory may be an actual handicap, leading its possessor to depend upon more or less well digested information, with failure to give the all important powers of ratiocination and imagination due exercise. While many men of genius have possessed prodigious powers of memory, a study of their history will show that their other faculties were equally brilliant and that the memory was employed in its proper function as a warehouse of materials. While teaching a class of small boys some years ago, the writer required them to reproduce in their own language a short selection read aloud to them. It was necessary to give one of the best boys in the class a low mark, since his too perfect memory enabled him to reproduce the selection, not in its main features through the exercise of his original powers of expression, but, on the contrary, almost verbatim. Many other instances will recur to readers of history, of men famous for their vast erudition who, nevertheless, made but little impress upon their times. Such men resemble those unfortunate ants whose fate it is to cling supinely to the walls of the cell with their bodies distended with honey to serve as magazines of nourishment for their more active nest mates.

An intellectual capacity which is extremely valuable in many lines of endeavor, is the power of making *constructive combinations of a technical nature.* Such a power is evidently dependent upon a very complex mental process, and this makes it all the more difficult to devise suitable tests.

What is known as a sense of space, *i.e.*, a correct judgment of spatial dimension, whether by the eye or by the coordination of various muscles in the hands and arms or legs and feet, is a very important matter not only to engineers and architects, but also in large measure for mere workmen, mechanics and laborers. Such a faculty, for example, is very useful to a man in comprehending mechanical drawings and specifications. It is a matter of common observance, indeed, that men in whom this space sense is strongly marked, quickly advance above their less gifted fellows. A common way in which this capacity is tested is to send the subject being examined to select tools according to a certain pattern, for example, he may be given a technical drawing showing a simple screw nut in side view and in section. He is told that he must pay special attention to the form of the outline but need not consider especially the more lightly traced lines giving the dimensions. He is then sent to select the given tool from among a large number, some of which are very like it while others are more or less different lying together upon a table. Here again some applicants make the correct selection easily and promptly while others are slow and hesitating in their choice. The unskilful, those lacking in power of attention, make many mistakes—for example, instead of bringing the nut which they were asked for they may select a spiral spring because it was mentioned to them that the nut had a spiral thread, and because their memory as to the outline was at fault.

In many trades delicacy of tactile perception is extremely important. A relative of the writer who eventually became very wealthy remarked in speaking of the outset of his career that he had voluntarily resigned an excellent position with a wholesale dry goods company for the reason that he found his sense of touch insufficiently sensitive to discriminate between various grades of woolen, linen and cotton goods. Few young fellows of his age, however, have sufficient self-knowledge and forethought to make such a decision for themselves, hence it is cus-



FURTHER LIGHT ON THE RELATION BETWEEN STIMULUS AND REACTION IS GOT FROM THESE TESTS

Left: Perception and reaction intervals are tested here, where the boy must let go the switch on the appearance of a certain light among the many on the board before him. *Right*: Another test similar to the first one pictured; here the subject tries to give repeated hammer blows with exactly the same force

tomary to make tests both as to the sensitiveness of the touch, and of the joints, whose suppleness and precision of action is also of great importance in all those trades that involve the handling of materials, as in the case of carpenters, joiners, turners, etc. In psychological laboratories this faculty is frequently tested by means of a bolt fitter. This apparatus consists of two concave chucks which are made to approach or recede from each other by means of a wheel turned by hand. The subject is told to turn the wheel until the bolt "fits" the cavity enclosed by the chucks, *i.e.*, until it arrives in a certain precise position, which is minutely described to him previously in the simplest and most unmistakable terms. Here again we observe that some boys or men are able to place the bolt in the right position almost immediately. This placing of the bolt is repeated several times and the degree of accuracy is read each time on a hundred-millimeter scale. By averaging the results with allowance for certain "subjective" errors, the general degree of sensitiveness in the articulation of the wrist is found.

Clearly enough there are certain forms of tests and questions which can be better given by practical mechanics, foremen and managers, than by professional psychologists, but it is more and more becoming to be understood that the cooperation of these two classes of men, together with that of men grounded in economics, is requisite for the obtaining of the best results in this field. This is very ably brought out in a recent book by Dr. Henry C. Link, entitled "Employment Psychology," in which two sets of ten questions each were prepared for candidates for the position of gun assembler. The first group of questions with a typical set of satisfactory answers follows:

1. Q. What experience have you had as a gun assembler? A. More than five years on various makes, both rifle and shotgun.

2. Q. What experience have you had as an assembler other than on guns? A. Several years' experience on sewing machines and typewriters.

3. Q. What kind of work requiring particularly close filing have you done? A. Small tool-work.

4. Q. Have you any trouble with your eyes? A. No.

5. Q. Are you nervous? A. No.

6. Q. Have you had such experience in shooting guns as to be able to determine the requirements of a finished gun? A. Rifle, target, and shotgun practice.

7. Q. How long have you held each job? A. More than a year.

8. Q. What are your habits? A. Sober, and never lose my time.

9. Q. Have you had much trouble with the foremen for whom you worked? A. No.

10. Q. Does gun assembling particularly appeal to you? A. Yes.

The second set of questions, with typical answers by the same candidate, was as below:

1. Q. What experience have you had as a gun assembler? A. More than five years on various makes, both rifle and shotgun.

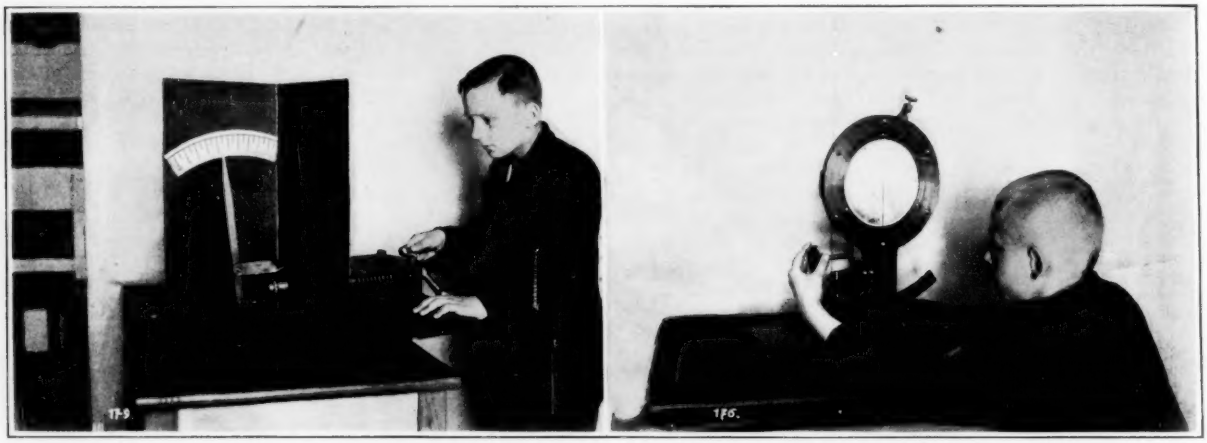
2. Q. Name the most important adjustments on a gun. A. Breeching, locking, trigger, chamber, firing pin, barrel and sight alinement.

3. Q. Why do you consider breeching important? A. Because if the gun is not breeched correctly the cartridge will be loose and cause unnecessary wear on chamber.

4. Q. Why lock? A. If a lock is not correctly adjusted the gun may fly open and injure the operator while shooting.

5. Q. Why trigger? A. If trigger pull is too light, gun may jar off and injure some one, or if too heavy will cause poor targeting.

6. Q. Why chamber? A. If the chamber is too large the shell will swell and cannot be extracted in the regular way.



TESTS IN WHICH THE SUBJECT'S CAREFULLY FORMED JUDGMENT IS INVOLVED

Left:: The boy is asked to turn the screw several times through exactly the same distance, and his success measured by the advance of the pointer over the scale. *Right*: The would-be apprentice in the machine trades must be able to set up a right angle with the two pointers without material error

7. Q. Why firing pin? A. If the firing pin is too long there will be the danger of premature fire; if too short, of misfire.

8. Q. Why barrel? A. If there is a seam in the barrel when shot it will burst open, and if the barrel is not straight the gun will not shoot straight.

9. Q. Why sight alinement? A. The alinement of sight is essential to correct shooting.

10. Q. What experience as an assembler other than on guns? A. Have had several years' experience on sewing machines, typewriters, etc.

11. Q. What kind of work requiring particularly close filing have you done? A. Small-tool work.

These are valuable questions, because they require specific answers about concrete and specific elements in the work of gun assembling. However, definite as they are, they could not be used as they stand with any certainty as to their value. It is first of all necessary to experiment with these questions on a sufficient number of men actually engaged in the work, in order to find out whether the questions are such that the best workers obtain the highest grade in the test, and the poorest workers the lowest grade. In other words, it is necessary to find the correlation between the performance of the men in the test and their actual ability at their trade. Moreover, it is also necessary, by a careful process of trial and error, to eliminate ambiguous words, catch questions, "guess" answers, and

questions which permit a lengthy or indefinite explanation. In short, trade tests, whether in the form of questions or any other form, must be developed, by means of the technique of psychology if they are to be at once practical and reliable.

A further development of the question method is to base the questions asked on pictures or blueprints. A tool maker, for instance, might be shown a group of blueprints calling for operations on different machine tools and asked to name, offhand, various machines which are required for each. A machinist might be shown a picture of a collection of machine parts and asked to name them. A third method is to give the applicant an opportunity to demonstrate his ability by giving him some representative task to perform.

In formulating and standardizing tests for trades and other technical occupations, too much emphasis cannot be placed upon the close cooperation between the technical expert and the psychologist. The former alone can supply the facts necessary for the meat of a test. However, it is equally true that the technical expert cannot, as a rule, use his knowledge in the manner required by an employment test or interview. This deficiency must be supplemented by the psychologist, whose assistance in formulating the details and standards of a test and in giving it an experimental trial is indispensable to its success.

The second list quoted was the result of a conversation between the foreman who formulated the questions of the first list and a psychologist who pointed out to him their inadequacy. The foreman was intelligent enough to perceive the truth of the criticism and expressed chagrin at its character, after which he made out the second list which is clearly far superior.

Perhaps one of the most suggestive ways of indicating in brief the sort of tests employed is to give a numerical list of tests, some of which are of general applicability, while others are required only in special lines:

1. Eyesight test. 2. Card sort (simple). 3. Accuracy. 4. Steadiness. 5. Cancellation. 6. Number-group checking. 7. Tachistoscope. 8. Arithmetic. 9. Card sorting. 10. Hand directions. 11. Oral directions. 12. Context reading. 13. Substitution, letters. 14. Spelling. 15. Handwriting. 16. Three-hole tests. 17. Filing, alphabetical. 18. Filing, alphabetical (cards). 19. Dictation, typing. 20. Grammar. 21. Substitution (numbers). 22. Comptometer adding. 23. Comptometer extending. 24. Filing, topical, etc.

EFFECT OF FEEDING TADPOLES WITH THE THYROID GLAND

ONE of the most interesting domains of recent physiological research is that of the effects produced in the animal economy by the thyroid gland. The secretion from this gland not only plays an important role in the growth of children but very recently the claim has been made by a well-known psychiatrist that it is one of the factors controlling emotion in adults. So impressed was a learned judge by the weight of this argument that he suspended judgment in the case of a woman arrested for shoplifting in a New York department store, because of the abnormal condition of her thyroid gland, and physiologists are now awaiting with interest the result upon her morals of treatment of this abnormality. In this connection it may be of interest to give a brief description of some recent experiments concerning the influence of this and other internal secretion glands upon the growth and development of frog larvæ. The well-known German physiologist, E. Abderhalden, and his colleague, O. Schiffmann, have described some of their recent work along this line in *Pflügers' Arch. f. d. ges. Physiol.* (Berlin) Vol. 183, pp. 197-209, 1920, an abstract of which we take from *Die Naturwissenschaften* (Berlin) for April 8, 1921.

It was the object of the experimenters to study the influence of certain substances by histological methods. The external alterations of the growth and development of the tadpoles gave results corresponding to those described earlier (See Romeis). Fresh human thyroid glands were fed to the tadpoles in the form of three extracts which were prepared in different manners and which produced practically the same effects, but in varying degree. The alterations in the intestine were made the subject of special study. The animals fed upon the thyroid gland exhibited an alteration both in the course and in the final result of the metamorphosis of the intestines; and while in the control animals the epithelial cells of the intestine which degenerate during the process of metamorphosis contained only a few thick lumps, varying from yellow to brown, in the case of the animals experimented upon these lumps or masses formed a principal sign of the degenerating epithelium. In the control animals nests of cells are found behind the epithelium and the new epithelium is produced by these. But these masses of cells are lacking in the thyroid-extract animals. In the latter the remainder of the old epithelium appears to draw together again and thus form a new epithelium and later, by reason of this, the degenerating masses find their path into the intestine lumen. These masses were first gradually absorbed into the wall of the intestine. The influence of the thyroid-gland feeding upon the endrendocrin glands was especially studied, exact measurement of the thyroid gland, the thymus gland and the hypophysis being made, and their magnitude compared with that of the brain and of the diameter of the animal. These experiments, however, led to no satisfactory result, since even in the control animals there were considerable differences of size.

TOTAL REFLECTION OF LIGHT IN WATER BY ANIMALCULES

IT is natural to suppose that light penetrates clear water as it does glass. The Prince of Monaco, one of the greatest students of marine life, has shown, however, that there are myriads of animalcules in sea-water and that they cause almost a total reflection of a beam of light projected into the water. Therefore, water is not like glass in its transmission of light.

In connection with submarine detection studies, Mr. Elmer A. Sperry, member of the Naval Consulting Board, made some elaborate experiments on projecting light through water, from which instructive results were obtained. An electric light was used having a sixty million candle-power beam, which could be seen through air for 62 miles (150 amperes, 75 volts, condensed and directed by a 36-inch projector).

This light was placed in the bottom of a steel well resembling a boiler 25 feet long, with an opening in its side near the bottom 40 inches in diameter, in which a plate-glass window one inch thick was sealed. There were several tons of lead in the bottom of the well so that it would sink vertically to any desired depth. It was hung by a bale from a crane on a large barge.

The light was first tested in the muddy waters of the New York Navy Yard, at a depth of 10 or 15 feet below the surface. There was a total reflection of light, but this was attributed at that time to the great muddiness of the water. A luminescent sphere approximately 80 feet in diameter surrounded the window. This luminescence was wonderfully brilliant and acted like a fog to obscure vision. Brilliancy of luminescence seemed to be about the same at all points of the sphere, even exactly back of the well in the rear of the window through which the light was projected.

Experiments were then made in clear ocean water near the easterly end of Long Island. Here also it was found that the beam of light could not be projected through the water as had been hoped, and that a globe of luminescence was produced as in the experiments in the New York Navy Yard. The globe of luminescence was visible through this comparatively clear water for possibly a quarter of a mile, and it could be used for the purpose of silhouetting mines, anchors, cables and other objects of this nature, against its white background with very great distinctness, up to this distance of a quarter of a mile.

The Significance of Size*

How Magnitude Conditions the Functioning of Living Organisms

By Dr. Otto Hartmann

IT is quite natural, of course, that the smaller animals should in general be more amenable to external influences than the larger ones, since both their muscles and their skeletons are lighter and more delicate. Few people realize, however, that the absolute size of any living organism, whether plant or animal, is by no means a matter of indifference. Consider, for instance, a blade of grass, which is possibly 1 m. in length and 2 mm. in thickness. Now imagine this multiplied by 10, so as to be 10 m. tall and 2 cm. thick. We see at once that such a gigantic grass blade would be liable to be broken by the lightest breath of air or even by its own weight. The lesson to be drawn from this example is that when any given organism is increased proportionately in all its dimensions, length, breadth, and height, the purely physical conditions which control it may be thereby altered so as to prevent it from being viable, i. e., capable of continuing its existence.

THE ECONOMY OF ANIMAL HEAT PRODUCTION

Let us first consider the production of animal heat. It is obvious that the warm-blooded animals possess internal stoves, so to speak, which enable them to maintain the bodily temperature at a given point, even when the air or water which surrounds them is much colder; the loss of heat abstracted by the colder medium is compensated by the animal heat produced by chemical changes in the body. The more rapid this loss of heat the greater the efforts of the animal must be to replace it. It is evident that this loss of warmth, due to a colder medium, takes place only upon the surface of the body, and because of this that it must increase as the amount of surface increases. But the heat *production* of the body takes place within the interior of the latter, in its tissues, muscles, glands, etc., and must correspond, therefore, roughly to the *volume* of the creature — just as a stove produces more warmth the bigger its fire box, while it gives off more the greater its surface. A moment's thought will show us, therefore, that if any given animal's size be increased to tenfold, the surface will be increased according to the square, whereas the volume will be cubed. The relation of the surface to the volume is altered, although the animal has not been changed in form. Obviously, therefore, if we have two animals of like form but different size, the greater of the two will lose less warmth in comparison to its heat production than the smaller.

As a matter of fact, indeed, there is in the case of very small animals a really enormous surface radiation of heat in comparison to the heat generated by the body; thus we see that warm-blooded animals cease to be capable of living when the size becomes too small for the volume of the body to produce enough heat to make up for that radiated from the surface. On this account the smallest warm-blooded animals in existence, such as the dwarf shrew-mouse and the humming bird, must have a tremendous power of generating heat — a power supported by the food they consume. This at once enables us to understand why these small creatures require such enormous amounts of food in comparison to their size, and why they can support hunger for a much shorter time than larger animals can. This explains, too, the provisions against the winter cold so often found in birds and small animals — such as hibernation, refuge in caves and hollows, or the huddling together in crowds so as to reduce the surface radiation as much as possible. When birds slumber they protect their legs as much as possible by their plumage and stick their heads under their wings, thus assuming a nearly spherical form — a very significant fact, since the sphere has the smallest surface compared to its volume of any solid body.

THE ECONOMY OF WATER

Not only heat but moisture is constantly given off from the surface of the body, so that small creatures lose more in proportion than larger ones. There can be no direct comparison in this respect, however, since the loss of moisture is largely influenced by the nature of the skin, which is sometimes very thin and delicate and at others thick or well-armored.

There are some cases, however, where its larger proportional surface-area is an advantage to the smaller animal. Everyone is familiar with the dusty beam of light seen when sunlight penetrates through an aperture into a dark room. This visibility is due to the fine particles of wood, textiles, earth, etc., which are much heavier than air, but which remain floating in the latter or settle to the earth only very slowly, whereas larger pieces of material fall to the ground at once. The reason for this difference is the comparative proportion of the surface to the volume in the small particles and the larger masses. For example, a wooden ball 1 cm. in diameter will fall rapidly to the ground. If we assume the surface ($6 \pi r^2$) and the volume ($4/3 \pi r^3$) to be originally equal numerically, and then imagine this ball to be reduced in size till it is only one ten-thousandth part as great as before, then the surface will be ten thousand times as great in proportion to the volume as it was before. In a vacuum, to be sure, even so small a ball would fall to the ground as rapidly as the larger one, but the case is very different where the balls are surrounded by air or by water, for here the element of friction comes into play, and this is dependent upon the surface. This consideration explains at once why all organisms whose existence is passed floating in water, and particularly the minute creations known by the general term of *plankton*, are very small, for even if they are provided with floats in the form of spines, prickles, etc., which tend to prevent their downward fall, still the main condition of their viability consists in their small size. Among birds, too, we find that the larger species are apt to be poor flyers and often desert the air for a life on *terra firma*, as in the case of ostriches, barnyard fowls, turkeys, etc.

MAGNITUDE AND MOTION

As the size of an animal increases, the weight of the body augments much more rapidly than the available power of motion, since the latter is practically dependent upon the cross-section of the muscles, which increases according to the square of the linear dimensions, whereas the weight of the body increases according to the cube. This fact at once explains why insects and small animals are able to leap enormous distances compared with their size. Some of them, such as fleas, grasshoppers, and even small dogs, are able to jump many times the length of their own bodies — sometimes, indeed, a distance a hundred-fold as great — which is quite out of the question in the case of the larger animals.

In the same manner an insect undergoes no danger in falling from a tremendous height, even if its body possesses no protective armor. This circumstance, indeed, becomes a measure of protection, since when pursued the little creature simply lets itself fall from even a topmost bough and then hastily scurries away or else "plays dead." Even small mammals, such as squirrels, will throw themselves from the top of trees many meters high when in danger of capture, whereas larger animals would be crushed by a fall of equal distance.

But when one beholds a large bird slowly describing wide

*Adapted for the *Scientific American Monthly* from *Kosmos* (Stuttgart) for April, 1921.

circles in the air, with every motion expressed in harmonic curves, one is immediately struck by the difference which exists between this sort of motion and that of small birds and insects. The latter dart hither and thither with zig-zag motions, come to a sudden stop, and then fly off again with renewed rapidity. The smaller body, of course, possesses comparatively less momentum and is therefore capable of using its muscular power much more readily for the purpose of stopping, starting, and changing direction, even though the muscular framework is by no means so well developed as in the larger species, and the actual energy of motion is, consequently, far less. In order for large animals to move as skilfully and rapidly as the smaller animals, they would require an enormous muscular system, and this would tremendously augment the weight of the body; so that through these purely physical conditions there must be definite limits to the attainable size and power of motion among animals. The solidity of the tissues also limits the size of animals, and if a large animal were able to check a sudden motion as rapidly as a smaller one can, it would literally risk being torn apart — so important is the inertia of large bodies which opposes any sudden alteration in their velocity of motion.

Every nature lover is familiar with the long-legged spider, the *Phalangium opilio*, which usually spreads its web on walls. It would be a physical impossibility for this spider to exist if enlarged to the dimensions of even a medium-sized mammal. Its long, crooked legs, upon which it supports itself in the midst of its web, would no longer be strong enough to support the weight of the body, but would inevitably bend and break. Moreover, the system of muscles would be too weak to move the enormous body and legs. Of course, the muscles would be enlarged in proportion, but we must remember that the supporting power of the legs and the strength of the muscles increase according to the *square* of the magnitude, while the weignt of the body and legs increase according to the *cube*.

Many interesting points present themselves in this connection, whose consideration, however, would demand a discussion of mechanical principles into which we can not here enter. We will merely remark that the *leverage* effects, such as are involved in the horizontal extension of the wings, feelers, etc., of insects would be so enormously increased by the supposed augmentation in size that the boneless substance of the insect's body would be unable to support the resultant strain. All horizontal extended members of plants and animals, such as limbs and branches, are necessarily small when their substance is soft and tender; when they are large, as in the case of big branches of trees, the material of which they are composed must be tremendously strengthened (as in the woody fiber of trees).

From the above remarks we see that manifold possibilities in the form and method of construction are open to small creatures which would offer insuperable difficulties from the technical point of view to large ones. This is why the many bizarre and monstrous forms found in small creatures are forbidden to large ones. Engineers, too, are familiar with the fact that the construction of small models is often quite an easy matter, whereas to develop them upon a large scale presents serious technical problems which can often be solved only by some new method of attack — in any case a simple enlargement of small models is quite out of the question. Static problems which are quite insoluble in the case of large animals simply do not exist in that of small ones. Flies, for instance, are capable of crawling up smooth vertical walls because the force of gravity is readily overcome by their muscles and joints, supported by the protective chitin shields of their legs. But the resistance to the force of gravity would be out of the question in an animal a hundred times as big.

Small creatures are afforded an infinite variety of modes of existence merely through their size. What makes it possible for the long-legged water-flea to run lightly over the surface of a sheet of water? If we observe it closely we see that the end of each of its six long legs makes a slight depression where it rests upon the surface. The surface is elastic in fact and acts like a spring mattress. This physical basis of this mode of action may be explained as follows: The separate molecules of water cohere with considerable firmness and therefore offer a certain degree of resistance to penetration by any solid body — but this is true only in case the said body can not be *wet*, i. e., if it has a composition like that of the *fats*. This resistance is a result of the *surface tension* of the liquid, which acts like a stretched membrane. This is sufficient to support the weight of the water-flea, though it would be practically negligible for ourselves. But while this firmness of the surface of a liquid affords great advantages from one point of view to such small creatures, it is terribly dangerous when looked at from another angle. For if such a small insect becomes wet all over, it is immediately drawn under the "skin" of the water and the very firmness and elasticity of this skin, which were such a help when the insect was on top of it, becomes a means of destruction, since now the little creature is, as it were, inclosed in an elastic sack, from which its utmost efforts frequently fail to free it. Only when the water evaporates can it use its legs and wings once more. And if the liquid is not pure water, but contains viscous impurities, it is condemned to perish. Thus we see that physical forces capable of strongly affecting the fate of small creatures, either for good or for ill, may be quite unimportant to large ones; e. g., small birds and insects may be caught by ordinary viscous materials (such as bird-lime), while it is impossible to trap mammals in this way. Through this circumstance viscous juices are tremendously important to plants by affording them protection against attacks by insects.

Of great importance, too, is the firmness of the tissues of support in both plants and animals as related to their size. If we imagine a wooden column of a given size and thickness to have its dimensions increased in the same ratio, then we must not forget that its weight, i. e., the pressure it exerts upon its base, augments according to the cube of the increase in magnitude, while the supporting power and firmness of the lower layers of the column increase only according to the square. Hence if we continue to increase the size of such a column we must finally reach a point at which the weight is too great to be supported by the lower portion of the column. If we wish to make the column stable we must increase its thickness, especially at the bottom, in a greater ratio than the height. It is at once obvious that these considerations are of the greatest importance in the kingdom of plants — in other words, the bigger a tree the thicker its trunk must be. Of course, this comparison must be confined to plants containing roughly the same proportion of woody fiber, since other things being equal, a plant with more such fiber has a greater supporting power than one with less, and may therefore have a more slender stem than the latter. If, for example, we imagine an Erika or a two-year-old sapling to be increased in size a hundred-fold, clearly such a structure would be mechanically impossible, since the stem and branches would be too slim to support the great increase in weight. The resistance to *bending* affords another interesting point of view. Let us return to our first example of the blade of grass. If it were increased a hundredfold in length and thickness, a breath of wind would break it; for when the huge mass of such a giant grass-blade lost its equilibrium ever so slightly its degree of thickness and firmness would not suffice to make it properly resistant. The weight of the upper portion of the blade, when brought out of equilibrium, increases, as we have so often seen, according to the cube, while the solidity increases only according to the square, provided, of course, that the substance of the glass blade remains the same; furthermore, since the vibratory motion of large masses tends to produce still greater forces which increase according to the fourth power of the magnitude, the case would be still more extreme.

By comparatively stronger growth in thickness the plant

compensates for these disturbances of its mechanical equilibrium. But even in this manner it cannot proceed very far, since this greater thickening of certain portions increases the weight, so that finally certain limits to growth and size are inevitably attained under the conditions involved in the solidity of the structural material — in this case, of course, wood. It is probable that the mammoth trees of California, whose trunks have diameters as great as ten yards, closely approximate these natural boundaries. But such gigantic structures are always uneconomic with respect to vital conditions, since they involve a disproportionate use of supporting and structural material, whereas life always thrives best when it follows the golden mean of neither too small nor too large, thus avoiding the difficulties and injuries to which extremes lend themselves.

I have already called attention to the fact that small plants often extend their branches horizontally. It would be mechanically impossible for such a plant to be magnified to the dimensions of a tree, since the weight of the branches increases much faster than their resistance to bending, which depends upon the transverse diameter. The same thing holds true for the effects of *traction*. If we imagine the pendant leaves of grasses to be magnified a hundredfold we at once perceive that the resistance of the leaf tissue is much too weak to bear the weight of the leaves, since this increases more rapidly than the supporting power of the transverse diameter. Thus we see that the observation we have already made in the case of animals also holds good in the kingdom of plants, namely, that the simple mechanical-physical conditions which obtain in small plants allow of an enormous variety, whereas the larger plant-structures are more limited in their range.

A meadow whose growths were increased to the size of a forest would be a monstrosity from the mechanical point of view, and I cannot better express the significance of the size of living organisms as regards their structural plan, their arrangements for securing firmness and solidity, etc., than by suggesting to the reader that he lie down in a meadow and after studying the tiniest plants therein, imagine them magnified to the size of a mighty forest.

The same law that governs plants with their structure of woody fiber holds good for the higher animals — the vertebrates with their *skeletons*.

There are the same natural limits to the size of the vertebrates, since very large ones, such as the now extinct saurians, find it difficult to move because of the weight and thickness of their bones and are not therefore perfectly viable. In the wren the bony skeleton comprises 7.1 per cent of the mass of the body; in the shrew-mouse, 7.9 per cent; in the goose, 13.4 per cent; in the dog, 14.0 per cent; in man, 17 to 18.0 per cent. Thus we see that life is governed by the materials and conditions it works with — like a sculptor, it achieves its highest perfection when substance and form are most perfectly adapted to each other.

The Lines of the Spectrum*

Their Relation to Modern Theories of Physics

By P. Zeeman

Of the Laboratory of Natural Sciences of the University of Amsterdam

WE omit the first portion of this article since it consists largely of a historical résumé of the work done by the late Augusto Righi and his predecessors in the field of spectroscopy with which most of our readers are, of course, more or less familiar. The latter part of the article, however, is of value in showing the most recent developments in this field and its bearing upon present day physical research.—EDITOR.

That which we term at the present day the science of spectroscopy was in the beginning merely a form of chemical analysis, known as spectrum analysis. But the great delicacy of the details revealed to us by the spectroscope and the precise measurement which this apparatus enables us to make, have given us a means of advancing our knowledge to a much greater extent than was dreamed of by Kirchhoff and Bunsen; and now-a-days the art of spectroscopy has become at once the most delicate and the most potent of the methods at our disposal for the study of the properties of atoms and of molecules.

In studying the spectra of the various elements it has been remarked that the spectral rays are frequently arranged in a very regular manner. This arrangement is simplest of all in the case of hydrogen. Balmer succeeded in establishing a simple formula which enables us to indicate with great precision the locations of the rays in the spectrum. . . . Somewhat later other physicists propounded formulas for a large number of elements, all of which were likewise comparatively simple.

In 1896 I was able to prove by making use of a Rowland space lattice that *under the influence of a powerful magnet a source of light emits a different spectrum.* In the simplest case of all each ray of the spectrum is decomposed into two or three components. We observe moreover that the rays do not emit natural light, but on the contrary, the simplest form of light known to us namely, polarized light, whose direction of vibration depends in a very simple manner upon the direction in which the magnetic force is exerted. All of this except the magnitude of the effect produced Lorentz was able to predict by taking as a starting point his theory with respect to optical and electrical phenomena—a theory which was brilliantly confirmed by later experiments. Lorentz's theory assumes that there exists in each atom a vibrating electrified particle, *i.e.*, an electron, which is the cause of the emission of light. The magnetic field is capable of influencing the movement of the electron and modifying the emission of light. It has been possible to deduce by means of experiment the fact that the vibrant particles are negatively charged, and the measurement of the distances between the components of the triple line has taught us the ratio between the charge and the mass of the particle. This same ratio was likewise found by means of the celebrated experiments made by J. J. Thomson and Leonard in the case of those electrons whose projection constitutes the cathodic rays in a tube containing a rarefied gas. The mass of the electrons is equal to 1/1840 of that of an atom of hydrogen.

It is a remarkable circumstance that all the rays in the same spectral series are decomposed in the same manner. Everyone who observes this decomposition of spectral rays finds it a very charming spectacle. At times this decomposition is much less simple. But every observer can but feel that there exists within the atom a marvelous regularity with respect to the movement of the electron, and that this regularity is capable of manifesting itself when it is modified by the magnetic force.

While a magnetic field decomposes all the rays of all the elements and while the magnitude of this effect varies very little as respects the different elements, there is one effect produced which varies considerably; let us examine this.

The question as to whether an *electric force* also exerts an influence upon the movement of the electron in an atom emitting light, was answered in the affirmative by the admirable

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discoveries made by J. Stark at Aix-la-Chapelle in 1913—the discovery of the electrical decomposition of spectral rays. The greatest difficulty met with in investigating an electrical spectral effect resides in the application of field. Luminous gases act as conductors and as a result of this an electrical field almost immediately disappears. However, by making use of tubes containing rarefied gases in which the rays termed "canals" emit light and in which the conductivity of electricity is feeble, Stark was able to apply very intense electrical fields within a very small amount of space. The rays of hydrogen, of helium, and of lithium were the first ones which he examined. But it is very remarkable that the *diffused* rays of a spectrum are strongly influenced, while the clearly defined rays are but slightly affected. The case is here very different from that of *magnetic* decomposition, in which the rays are not separated from each other as regards the point of view of the degree of their decomposition. There is, in fact, a difference in every detail between electrical decomposition and magnetic decomposition; the only analogy that exists between them consists in the fact that polarized vibrations are obtained in both cases.

The existence of spectral series and the phenomena of magnetic and of electrical decomposition of the spectral rays, have revealed to us one of the most important mysteries in the realm of natural science.

Let us now consider for a few moments the highly promising attempts that have been made to discover the key to this mystery by the formulation of a hypothesis concerning the constitution of the atom.

Rutherford has established a theory respecting the constitution of the atom which is based upon a very large number of experimental data. According to this theory atoms consist of a positive nucleus having a positive charge surrounded by negative electrons which are attracted by this nucleus. There are excellent reasons for supposing that this positive nucleus is very small and contains, so to speak, practically the entire mass of the atom. The electrons are the ordinary electrons of which we have already spoken and their diameter is 1/40,000 part of that of an atom of hydrogen. In the solar system the diameter of the earth is 1/20,000 part of the diameter of its orbit around the sun. If, therefore, we let the earth represent an electron then an atom is a sphere having a sun as a center and a radius equal to double the distance of the earth from the sun. The electrons in the atom revolve around the nucleus; from many points of view, therefore, an atom is comparable to a planetary system.

By applying to the movement of the electron, which revolves within the atom as imagined by Rutherford, Planck's theory of *quanta* Bohr has succeeded in evolving a very simple explanation of series of spectra.

Bohr's Theory.—According to Bohr's theory an electron may revolve within an atom of hydrogen around the positive nucleus in circles, *but only in circles having definite radii.*

An emission of light occurs when the mobile electron "jumps," for reasons as yet unknown to us, from one of these definite circles to another. So long as the electron is revolving in the same circle there is no emission of light. The point last mentioned is a very bold assertion, which is in conflict with classical theories of electrodynamics, and even a few years ago a candidate for a doctor's degree in physical and mathematical sciences would have been very rash to state such a belief, which might have cost him dear at the hands of the Board of Examiners. And yet by means of these hypotheses Bohr has found an explanation both for the stability of the atomic model and for the fineness of the spectral rays emitted. The beauty of Bohr's theory resides in the first place, in the fact that not only does it explain the general laws which control the series of spectra, but it also enables us to make an exact calculation, taking as a starting point other physical magnitudes, of a constant which is found in the formulæ of spectra and whose significance we should otherwise be unable to comprehend. Furthermore, this theory enabled Bohr to make the prediction that there must exist within the spectrum of hydrogen a series in the ultra-violet, and as a matter of fact such a series was later discovered by Lyman.

According to Bohr there is within luminescent helium an electron which revolves around a nucleus having a mass which is four times that of the nucleus of hydrogen and a charge twice as great as that of the hydrogen nucleus. While the mass of the electron is negligible with respect to that of the nucleus, the characteristic number in the spectral series is *four times as great for helium as for hydrogen.* It is true, to be sure, that the nucleus is itself not entirely motionless, but it merely describes a small circle around the common center of gravity of the nucleus and of the electron. If we take this circumstance into account then the number 4 must be replaced by 4.001635; and as a matter of fact the spectroscopic observations made by Fowler had yielded the number 4.001632—which agrees quite magnificently with the theoretic figures.

Planck's Theory Concerning Quanta.—The theory of the spectral rays will always be connected with the name of Bohr and every portion of this theory which is capable of being represented by entire numbers at once recalls to our minds the name of Planck and his theory of quanta.

Sommerfeld's Theory.—A new development of Balmer's theory of the series which is in conformity with the atomic model of the Rutherford-Bohr type was suggested by Sommerfeld. Whereas Bohr assumes that the orbits of electrons are circular alone in form, Sommerfeld extends the application of the theory by assuming the existence of non-circular orbits—of *elliptical* orbits in the case of hydrogen. But what strikes us as still more beautiful in this idea is that, taking as a starting point the formulas upon which the theory of relativity is based, *i.e.*, taking into account the variation of the mass of the electrons with their velocity, Sommerfeld has succeeded in furnishing an explanation of the details of the structure which is exhibited by a great many spectral rays. The introduction of the mechanism of the theory of relativity into these questions is made necessary by the fact that the velocities of the electrons in the atom are not very small in relation to the velocity of light.

The study of the fine structure of hydrogen rays and other similar rays has enabled us to subject Sommerfeld's theory to the control of experiment. Such a control experiment may be made indirectly by means of an observation of the effect discovered by Stark, *i.e.*, of the electrical decomposition of spectral rays under the action of an electrical field, when the electron is moving, therefore, at one and the same time under the influence of the nucleus charged with electricity and under that of an external field. Einstein has developed a theory of this phenomenon and has deduced a formula of electrical decomposition which contains only known magnitudes. The accord found between this formula and experimental results is very striking, and this forms a new proof of the correctness of the model of the atom suggested by Bohr.

Paschen's Researches on the Spectrum of Helium.—But a direct confirmation of Sommerfeld's theory has been furnished by the extremely precise and careful researches made by Paschen with respect to the spectrum of luminous helium. By producing a powerful electrical discharge in a tube containing helium together with a trace of hydrogen, Fowler found a series of rays which, according to the formulas proposed by Bohr, belong to helium and not to hydrogen, as had been first supposed. All these rays discovered by Fowler have been subjected by Paschen to an extremely minute spectroscopic analysis. Thanks to the collaboration of Paschen and Sommerfeld it has been found possible to interpret fully the experimental results. By means of measurements made upon the photographs obtained by Paschen it has been found possible to confirm Sommerfeld's theory down to its smallest details.

SUMMARY

To sum the matter up, Bohr's theory regarding spectra lent peculiarly great probability to the Rutherford-Bohr model of

the atom. It must be confessed, of course, that the theory still presents great obstacles. The essential difficulties encountered reside in the fact that it is necessary to assume, as does Bohr, that an electron revolving constantly in the same orbit does not emit any radiation, and it is also necessary to accept the ideas upon which the theory of quanta is based. Within the same theory, therefore, we have combined the old principles of mechanics and of electrodynamics which have long been proven and the new hypotheses which contradict the former. Apropos of this let me cite the words uttered by Poincaré in 1911 before the Solvay Council: "We must not forget that there is no proposition which cannot be readily demonstrated provided that we employ two contradictory premises in making our demonstration."

The three great theories of modern physics—the theory of electrons, the theory of quanta, and the theory of relativity, have been decisive factors in enabling us to comprehend the harmony of the phenomena afforded us by spectral rays. The great mathematician whom we have just mentioned would certainly have accepted, could he have been acquainted with them, the physical theories upon which Bohr's model of the atom is based, now that it has been proved possible to connect with each other a multitude of data by means of them and, above all, since these theories have enabled us to make predictions which have been later fulfilled.

ASTON'S METHOD OF MASS SPECTROSCOPY

OF extremely recent date are the thorough-going experiments made by the English physicist, Aston, with respect to the character of certain chemical elements. He has proved that a number of these at least, instead of being single elements as has been hitherto supposed, consist of isotopic mixtures. His method is purely physical in nature, since chemical methods would be unavailing to separate mixtures of this character, but, as a result of the difference in atomic weights there are certain differences in the influence exerted by an electric and magnetic field. This has enabled Aston to work out the details of the process by means of which isotopic mixtures can be recognized as such and the atomic weights of their constituents determined. Chlorine has always been one of the best known examples of deviation from Prout's hypothesis. This long-known chemical element has an atomic weight of 35.46; it is, therefore, not an exact multiple of hydrogen, but Aston has recently proved by his method of the "spectroscopy of masses" that chlorine consists of two isotopes having respective atomic weights of 35 and 37. Previous to this he was able to prove that the noble gas neon which has an atomic weight of 20.2, represents a mixture of two elements, called by him neon and meta-neon, whose atomic weights are again exact multiples of hydrogen—namely, 20 and 22. It is evident in this case that the isotopic mixture is not half and half in its proportions but that about 90 per cent of it consists of neon (20) while there is only about 10 per cent of the meta-neon (22).

In the course of the last few months Aston has succeeded in demonstrating that an entire series of chemical elements must really be regarded as isotopic mixtures and his experiments are still far from being concluded. We may mention the instances of bromine, of the noble gases, krypton and xenon, and of quicksilver; the latter consists presumably of a whole series of isotopes—five or more perhaps—whose atomic weights gradually increase from 197 to 204; the mixture of these produces the ordinarily given value of the atomic weight of mercury, 200.6.

These experiments whose deep significance with regard to chemistry in general cannot be denied, throw a new light upon the ancient hypothesis of Prout, and in the immediate future they will probably solve the problem as to whether we really may regard hydrogen as the basic element from which all others have been derived.

Thus we see how truly tremendous are the consequences which have followed upon the apparently trivial discovery some 25 years ago, of the radioactivity of uranium. Our concepts as to the very nature of the chemical elements have undergone a fundamental alteration. In the phenomena of the radioactive disintegration processes, we may observe the gradual breaking down of elements having a high atomic weight into those having a low atomic weight. And in these most recent investigations with respect to the isotopy of the ordinary chemical elements, we may perhaps find a proof of the upbuilding of the entire world of matter from a single primeval element—hydrogen.

EFFECT OF ULTRAVIOLET RAYS UPON THE EGGS OF THE SEA URCHIN

THOSE cytologists who undertake to study the respective parts played in the living cell by the nucleus and cytoplasm through the method of eliminating first one and then the other are beset by great technical difficulties because of the infinitesimal size of the elements of the cell. A recent investigator, M. Tchahotine, has invented a contrivance which enables him to direct upon a given point of the cell, for instance upon the nucleus, a beam of U.V. rays of extreme fineness (down to about 1 micron in diameter). The nuclear substances absorb these rays with more intensity than does the cytoplasm, and because of this fact the experimenter hoped to find himself able to exert upon the nucleus a localized and elective action, by means of an irradiation of very brief extent. However, in spite of the brevity of the operation he found that the cytoplasm was attacked by the passage of the rays to almost as great an extent as was the nucleus. When we study the mechanism of the manner in which the U.V. rays act upon the eggs of the sea urchin, we find that it is the plasmatic layer of the periphery which is chiefly sensitive, and which sets in motion the process of cytolysis. M. Tchahotine concluded, therefore, that it was necessary to find a means of rendering this layer less sensitive, in other words of *stabilizing* it during a length of time sufficient to produce a lesion of the nucleus. The results of his experiments are recounted in the *C. R. Soc. de Biologie* (Paris) for Dec. 1920. We take the following résumé from the *Revue Scientifique* (Paris) for March 1921:

The researches made by J. Loeb and R. Lillie upon the part played by various ions in the variations in the permeability of the cell have shown that while the permeability is augmented by the ions potassium and sodium, the ion calcium is antagonistic to them: it solidifies and renders less permeable the superficial stratum of the cell. M. Tchahotine conceived the idea of keeping the eggs, in order to irradiate them, in the solutions of these various ions. He first showed that sea-urchin eggs irradiated for 3 min. *in toto*, in sea water, succumbed at the end of 6 or 8 min. In a solution of potassium chloride or sodium chloride, they succumbed after the lapse of only 1 or 2 minutes. But they resisted as long as 50 min. in a solution of calcium chloride, and even for several hours if instead of using pure calcium chloride, which is always injurious, this was mixed with sea-water.

In order to act upon the nucleus alone, M. Tchahotine keeps the sea-urchin egg in a solution containing, per cc. of sea-water, 10 drops of calcium chloride; he compresses and flattens it in a minute tube of collodion, which diminishes the thickness of the layer of plasma between the nucleus and the surface of the cell, and he directs upon the nucleus a beam of U.V. rays during a period of 1 to 2 min. If this microscopic "radio-puncture" takes place at the instant when the egg is in the stage of 2 blastomeres, the evolution of the blastomere with the nucleus, which has suffered a lesion, is at once arrested, while the other continues to divide normally.

Barks with a Bite

Some of the Trees and Shrubs Whose Cortices Contribute to the Medicine Bottle

ONE of the pleasures which a small boy finds in roaming through the woods is the tasting of the various twigs which tempt him by their attractive odor or aspect. Thus he comes to know trees and shrubs not only by the look of leaf and bark and flower, but by the taste of the bark as well as of the fruit. This is exactly what was done by those earliest Boy Scouts, our primeval ancestors, and in this way they learned gradually that the aromatic or bitter flavors found in the bark of many plants indicate valuable medicinal properties, while others have a piquancy which made them prized as condiments. At the present time there is an enormous trade in various kinds of barks for the sake of the therapeutic value of their essential principles. While the retail drug stores still have various kinds of bark for sale from which infusions can be made at home, the great bulk of the trade is between the producer and the wholesale manufacturer who extracts the valuable principle and puts it on the market in the more convenient if more expensive forms of a prepared tincture, pill, powder, or tablet.

The United States Pharmacopœia lists 17 kinds of bark used in medicine, and no less than 12 of these are found in the United States. There are, in fact, no less than 35 kinds of bark altogether grown in this country, which are more or less widely used for preparing simple home-made remedies, although only 17 are classed as "official."

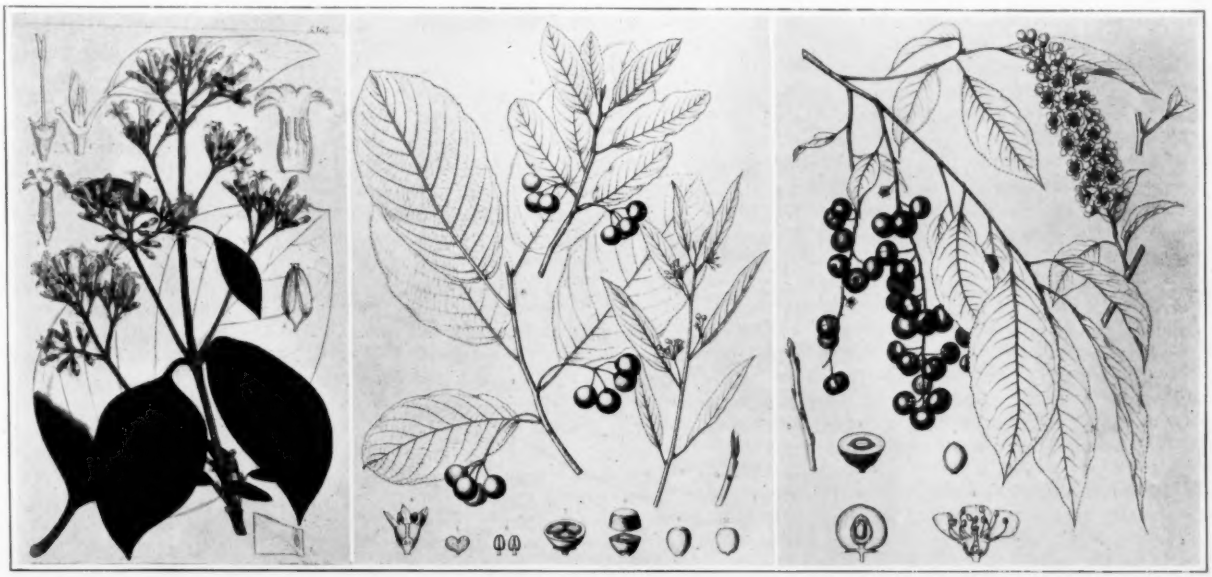
These barks fall into various classes according to their properties. Some are valued, for example, as febrifuges, chief of which, of course, is the Peruvian bark or cinchona, to which the world owes the priceless boon of quinine. A second class includes those which exert a cathartic or laxative effect and of these the most highly prized is the bark of the graceful little buckthorn tree found in northern California, and known by its Spanish name of Cascara Sagrada (sacred bark). A third class includes those which stimulate the flow of one or another of the secretions of the body, such as the saliva, gastric juice, perspiration, mucus, etc. Others are soothing in nature, such as an infusion of slippery elm, and may be used either externally in the form of poultices or for preparing soothing draughts in cases of sore throats, etc. Still others are said somewhat vaguely to possess "tonic" properties.

The various active principles found in the rind of plants are products of the vital activities of the plant, and are usually to be regarded as virtually excretions, *i.e.*, as substances which would be injurious to the life of the plant if they remained within its active tissues and which are, therefore, stored up in some convenient place, such as the bark, where they will, at least, do no harm and may, in many cases, be of actual service to the plant by protecting it from the enemies which might destroy it were they not deterred by the bitter or poisonous substances they meet with in bark, leaves, or fruit.

There are various ways of collecting bark and the matter is one of considerable importance, since by a wrong method it is easy to flay the tree alive, so to speak. This killing of the goose that lays the golden egg has been, and still is, all too common a folly in the United States. Except where very young twigs or shoots are used the outer corky layer is first shaved off before the bark is peeled, and this process is called "rossing." Then incisions a few inches wide are made, and strips of various lengths depending upon the nature of the bark are peeled off. Sometimes a long incision is made lengthwise in the bark of a branch or root and the bark is slipped off. In some cases it comes off readily, while in others it must first be pounded with a mallet to loosen it.

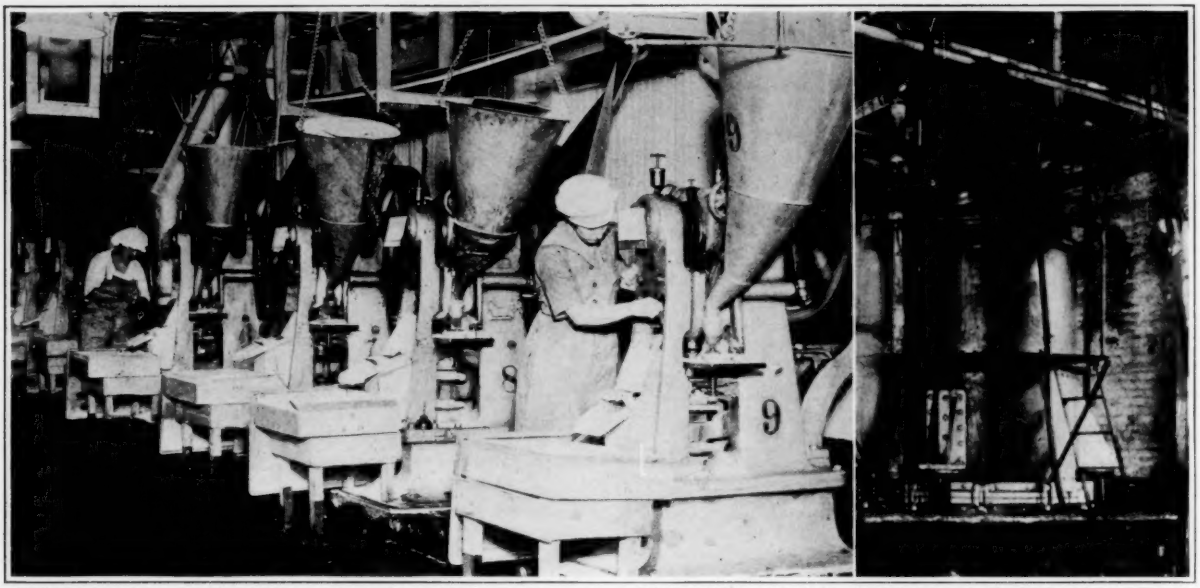
PERUVIAN BARK

This is a bark obtained from several trees belonging to the genus *Cinchona*, which grows spontaneously in many parts of South America, but more particularly in Peru. The tree somewhat resembles a cherry tree in appearance, and has white or pink flowers. This valuable medicine was formerly called Jesuit's Bark, from having been introduced into Europe by the members of that order settled in South America. They were instructed in its use by the natives of Peru, and it continued for many years a source of profit to the Order. Its botanical name given it by Linnaeus was derived from that of the Countess del Chincon, the lady of a Spanish viceroy, who had been cured by it. The tree from which it is obtained grows abundantly in the forests of Quito and Peru, and the bark is cut by the natives in the months of September, October, and November, during which alone the weather is free



CINCHONA OFFICINALIS *CASCARA SAGRADA* *PRUNUS SEROTINA*, THE WILD CHERRY

General appearance and botanical details of three principal medicinal-bark trees



EXAMPLES OF THE MACHINERY USED TO EXTRACT THE BITE FROM THE BARK AND MAKE IT AVAILABLE FOR OUR USE
Left: Still for producing fluid extract of cascara. *Right*: A battery of tablet machines, which in a year turn out fifteen tablets for each person in the United States

from rain. The bark is of three kinds—red, yellow and pale, of which the yellow and pale barks are considered the best since the active principle is stronger. The most valuable quality of all is of a pale reddish yellow tint; material possessing the color is called crown-bark. This is the original Peruvian bark. The yellow bark grows in Bolivia as well as in Peru while the red comes mostly from Ecuador.

QUININE

Quinine or quinia is a drug ($C_{20}H_{24}N_2O_2$) largely used in the cure of malarial fevers, in which it is regarded as a specific. It is also a valuable tonic. Quinine is one of the five most important of the 21 alkaloids obtained from the bark of the cinchona tree (Peruvian bark), the others being quinidine, cinchonidine, cinchonine and hydroquinine. The curative power of these alkaloids is accurately shown by the report, dated April, 1868, of a commission appointed by the British Indian government (Madras) after the suggestion of Clements R. Markham, C.B., F.R.S. Cases of fever numbering 2472 were treated, and the results showed failures per 1000 as follows: Quinidine, 5; quinine, 7; cinchonidine, 10; cinchonine, 23. Quinine alkaloid is seldom used, as it is very insoluble. The salt known as quinine sulfate is generally used but the acid hydrochloride (also called the "chlorate") is preferred by some careful physicians, and for children and the more susceptible the tannate is generally prescribed, in doses two or three times as large.

The average dose of quinine sulfate for adults in the United States is four to five grains every three or four hours beginning a few hours after a paroxysm and continuing until three hours before another is due, when a much larger dose is given. If, as is to be expected, no paroxysm occurs, the treatment is renewed for some hours on the second day, and then again on the ninth day, which completes the cure. In warmer and more fever-ridden countries, twice to three times this amount is given. Quinine is also used with great success as a prophylactic. Since 1902 it has been distributed free by the Italian government in the malarial sections. The preventive amount for adults is five to seven grains of the sulfate per day divided into two doses. Children receive two or three grains daily during the malarial season. As a tonic the best results are obtained by doses of one-half grain of the hydrochloride twice daily. In the administration of quinine it has been repeatedly noticed that toxic symptoms have been developed in some cases; and investigations have shown that in certain conditions both cinchonine and quinine develop poisonous isomeric forms, known as cinchotoxine and quinotoxine. This change takes place in the preparation of quinine when the drying heat (see below) is prolonged and acetic acid is present. The same changes have been noted at the temperature of the body in the presence of such acids as are sometimes found in the digestive tract, particularly acetic and citric acids. The poisonous symptoms are sometimes severe, and patients developing them should be treated with quinidine. The average consumption of quinine sulfate in the world is 15,000,000 ounces a year, and the approximate average net cost of production is 18 cents per ounce. The importations into the United States in the fiscal year ended June 30, 1918, were 3,273,628 pounds of cinchona and other quinine-yielding barks, valued at $810,775, and capable of supplying an average of 4 per cent (2,095,122 ounces) of quinine sulfate; and 1,445,702 ounces of quinine sulfate and other alkaloids and salts of cinchona bark, valued at $656,945.

To manufacture quinine the bark is ground to a powder that will sift through screens of 70 meshes to the inch, and mixed with one-third its weight of slaked lime, made into a paste with water and dried thoroughly at the boiling temperature of water. It is then powdered and mixed with petroleum and boiled about five hours, the alkaloids in the bark dissolving in the oil, or amyl alcohol may be used for the solvent. The powder is then allowed to settle, and the oil is drawn off and agitated with hydrochloric acid. The alkaloids in mixture, known commercially as quinidine, now leave the oil and go to the acid water, in which they are more soluble than in the oil. The oil and water separate upon standing, and the acid water is drawn off and neutralized with an excess of ammonia or soda, whereupon the quinine and other alkaloids are precipitated together. The alkaloids are redissolved in very dilute sulfuric acid and then the solution is almost but not quite neutralized by very dilute soda solution cautiously added. It is then heated to the boiling point and enough boiling water added to make 70 ounces of water for each ounce of mixed alkaloids. When the solution cools the quinine sulfate crystallizes out from the mother liquor which retains the other algaloids including quinidine from the mother liquor. The quinine thus obtained is purified by fractional crystallization.

Until about 1850 quinine was obtained only from South American cinchona bark. By that time it was in such world-wide demand that the price had risen to about $20 an ounce.

For this reason experiments were made by the Dutch in Java and the British in India to grow the tree. The conditions in Dutch Java were found to resemble closely those in its native habitat, where it is found to succeed best in an equable tropical temperature, at an altitude of from 5000 to 7000 feet, on a volcanic soil and with a rainfall of from 100 to 200 inches of rain per year. It is said, indeed, that these transplanted trees are now rather more vigorous than their forebears from Peru, because of the improved methods of cultivation discovered by Dutch agriculturists. The annual average export from Java is estimated (1918) at 16,500,000 pounds of bark, some of which yields as high as 10 per cent quinine while an average of 2 to 5 per cent is considered fair from the Peruvian bark.

CASCARA SAGRADA

Perhaps the most important of the barks native to the United States is the one known variously as chittembark, sacred bark (a translation of the Spanish name of the subhead above), bearberry tree, bearwood, shittim wood, Purshiana bark and Persian's bark. The pharmacopecial name is Rhamus purshiana. The tree occurs on the sides and bottoms of the cañons from the Rocky Mountains to the Pacific coast, extending north into British Columbia. It is of small size, usually from fifteen to twenty feet in height, the young twigs being hairy and the leaves rather thin. It belongs to the buckthorn family (*Rhamnaceæ*). The dark green leaves are elliptical in form, from two to six inches long, and about one to three inches wide, blunt at the apex or with a short sharp point, finely saw-toothed, rounded or slightly heart-shaped at the base, somewhat hairy on the lower surface, and rather prominently veined. The rather small, insignificant greenish flowers are produced in umbels, or clusters, and are followed by black, ovoid, 3-seeded berries, of a somewhat insipid taste.

The cascara sagrada of commerce occurs in curved or quilled pieces, the outer surface of which is reddish brown, and usually covered with growths of light-colored or grayish lichen, wrinkled and somewhat fissured. The inner surface of the bark is smooth and marked with very fine lines; at first the inside is yellowish, but with age it turns a dark brown color. The whole breaks with a short, sharp, yellowish fracture, and has a somewhat aromatic odor and an exceedingly bitter taste. The saliva is colored yellow by it, and anything with which the bark comes in contact for any length of time will also be stained yellow. Cascara sagrada is official in the United States Pharmacopœia.

The collecting season for cascara opens about the end of May or early in June and closes about the end of August, just before the rainy season sets in, as bark collected after exposure to wet weather is difficult to cure properly. After the strips of bark have been removed from the trees they are generally strung on wires to dry, care being taken not to expose the inner surface to the sun, the object being to retain the yellow color, as the action of the sunlight tends to darken the color, an undesirable result, inasmuch as it lowers the market price. During the drying process the strips curl up, forming quills; when sufficiently dried these are cut or broken up into smaller pieces.

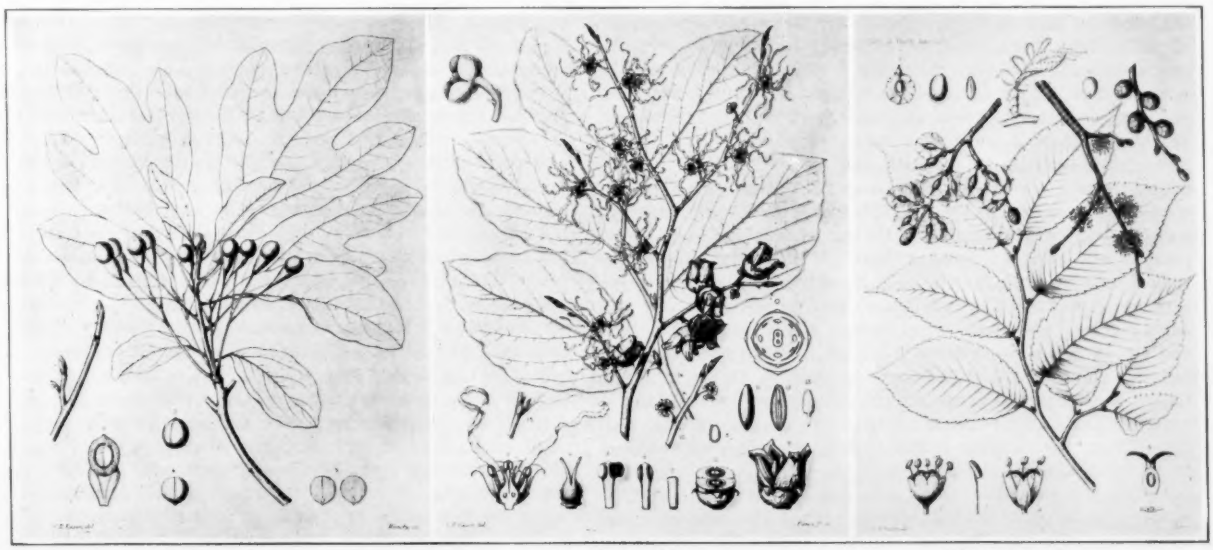
Several years are generally required after collection to age the bark properly for medicinal purposes, and the United States Pharmacopœia directs that it should not be used until at least one year after it has been gathered. Some crude-drug dealers undertake the "aging" of the bark themselves rather than leave it to collectors.

Many trees are annually destroyed in the collection of cascara sagrada, as they are usually peeled to such an extent that no new bark is formed. It has been estimated that one tree furnishes approximately ten pounds of bark, and granting a crop of 1,000,000 pounds a year, 100,000 trees are thus annually destroyed, and the world's consumption is said to be about 2,000,000 pounds a year. On account of the fact that cascara sagrada requires several years' aging before use, a shortage in the crop is not immediately felt. Cascara sagrada is a most valuable laxative, differing from other drugs of this character in that it tones up the entire intestinal tract, making long-continued and gradually increasing dosage unnecessary.

THE WILD CHERRY

This species is known to the naturalist as *Prunus secretina*, and to the pharmaceutist as *Prunus virginiana*. Its common names include wild black cherry, cabinet cherry, black choke, rum cherry, whiskey cherry, and Virginian prune-bark. It occurs in woods or open places, and is most abundant in the Southeastern States, but its range extends from Nova Scotia to Florida, westward to Texas, and north through Indian Territory, the eastern portion of Kansas, Nebraska, and South Dakota.

The elongated, drooping, pretty clusters of white flowers of the wild cherry are usually produced in May. The tree sometimes reaches a height of 90 feet, and a maximum trunk diameter of 4 feet. The trunk is straight and covered with a rough black bark; the young branches, however, are smooth and reddish. The reddish brown wood of the wild cherry



SASSAFRAS SLIPPERY ELM WITCH HAZEL

Three more familiar medicinal members of the vegetable kingdom, best known under their common names

is fine-grained, hard and is used in cabinet making.

The outer surface of wild cherry bark is smooth and glossy, green or brownish-green in color and marked with a number of pale colored lines or grooves, known to botanists as lenticels. The inner surface is rusty looking and marked with a network of minute crevices. It breaks with a short granular fracture. The value of the bark is due to the hydrocyanic acid which it contains, and it is this which gives it its aromatic bitter taste, which much resembles that of the kernel of the peach seed, or the traditional bitter almond that figures in every prussic-acid murder story. When the bark is soaked in water, the latter acquires the same taste and odor and astringency. The bark is collected in autumn, at which time it contains the greatest amount of hydrocyanic acid. The outer bark is removed, and the green layer underneath is stripped off and dried. The young, thin bark is considered the best and brings the highest price. The infusion is considered an excellent tonic and it is also sedative. It is likewise a common ingredient in many cough mixtures.

EMOLLIENT AND AROMATIC BARKS

Chief among the barks which supply soothing or emollient are the slippery elm, beloved of every boy who roams the woods and the witch-hazel. The commercial article consists of pale brown or whitish brown flat pieces tied in bundles, and it also occurs on the market in smaller pieces of uneven size, suitable for grinding purposes, but which brings a lower price. The flat pieces are of varying length and width, about an eighth of an inch in thickness, the outer bark having been removed in accordance with the requirements of the pharmacopœia, but sometimes patches of it are still found adhering. The flat pieces are tough and break with a fibrous fracture. The inner surface is yellowish brown and marked with fine furrows. Slippery elm has a faint peculiar odor and a mucilaginous but insipid taste. The mucilaginous character of slippery elm bark renders it useful in relieving coughs, and it is also employed in treating diarrheal complaints. It is soothing and allays inflammation and is also somewhat nutritious. In certain sections of the country poultices are made from the bark and applied to abscesses.

By witch-hazel or hamamelis bark, official in the United States Pharmacopœia, is understood the bark and the twigs of the witch-hazel. The bark is found in commerce in the form of quills, varying in length and width, and is sometimes a purplish brown on the outside, sometimes a whitish or grayish brown color; occasionally it is smooth with a few warty protuberances or numerous lenticels, and again it is furrowed and scaly, or even ragged. The inside is pale brown or yellowish, usually with long, straight lines. Sometimes fragments of the whitish wood are found adhering to the inner surface, and such bark should be discarded. Witch-hazel bark breaks with a weak fracture. There is a scarcely perceptible odor, and the taste is astringent and somewhat bitter. The tough, flexible twigs do not exceed one-quarter of an inch in diameter, are branching, yellowish brown to a very dark or purplish brown, faintly wrinkled lengthwise, and with small, round, light-colored lenticels. There is a small central pith, and the bark which surrounds the greenish white wood occupies about one-fifth of the radius. If the twigs are more than a quarter of an inch in thickness, there will be too large a percentage of wood, which is without medical value. Witch-hazel is used for relieving inflammation of various kinds and its soothing properties were known to the American Indians. The name "witch-hazel" is derived from the fact that formerly the forked branches were used as "divining rods," it having been the belief that these branches were endowed with a miraculous power of locating treasures, sources of water for wells, etc.

Among the aromatic barks we may mention that of the white pine, used in making cough syrup; the tamarack or larch, used as a laxative and diuretic; the bayberry, used as a tonic and astringent; the sweet birch, the magnolia (known also as cucumber tree, sweet bay, swamp laurel, umbrella tree, elk wood, etc.) which has a warm, spicy and slightly bitter and astringent taste, and which is used as a tonic and for exciting perspiration; and the sassafras, a favorite source of the domestic tonic or "spring tea."

Other barks which are less well known but have been used variously as tonics, astringents, diuretics, expectorants, etc., are those of the cascarilla tulip, poplar, the fringe tree, the white willow, the aspen, the butternut, the white oak, the blackberry, the American mountain ash, the prickly ash, the wafer ash, the black alder, the horse chestnut, the dog wood, the moose wood, the cramped bark tree, the black haw, the bitter and astringent taste, and which is used as a tonic and

PREVENTING CORROSION IN IRON AND STEEL UNDER WATER

F. N. SPELLER presented a paper under this title at the April meeting of the American Electro Chemical Society and included a summary of results on the corrosion of wrought iron and steel in hot water supply systems from a number of investigations. It appears from the work of the author and others that the intensity of corrosion under water is approximately proportional to the amount of oxygen in the water. If water pipes are to be protected from internal corrosion, say, at 180 deg. fahr., as in a heating system, it is not necescary to have the oxygen content lower than 0.4 cc. per liter. If steam boilers, superheaters and economizers operating at a higher temperature are to be protected the oxygen content must be less than 0.2 cc. per liter. Cold water, varying with the season of the year and temperature of the water, carries from 5 to 10 cc. of oxygen per liter. There are two systems by which the free oxygen may be removed.

The mechanical de-areating method consists in either spraying water into a high vacuum chamber with temperature and pressure control to remove the gases or the water may be passed over baffles under the same conditions. The air and vapor are drawn through a condenser which accompanies a transfer of heat to the incoming cold water and while the plant is necessarily expensive the results are satisfactory.

The fixing of the free oxygen by chemical combination amounts to so satisfying the oxygen with iron before it enters the heating system as to prevent attack upon the pipes. The heated water is, therefore, passed into a storage tank in which are placed a large number of expanded sheet iron plates calculated to afford from 60 to 70 square feet per cu. ft. of space. In half an hour at 170 deg. fahr. oxygen is reduced in this way to about 0.3 cc. per liter. Even when this treatment increases the carbon dioxide practically no after corrosion is experienced. Where water treated in this way is used for domestic purposes it is usually advisable to filter it.

In power plants satisfactory and economical de-aeration is obtained when open-feed water heaters operating at 180 deg. fahr. have their water space filled with thin steel lathing or if the water is caused to flow from the open heaters to a second tank containing steel scrap in this form. The open heater can be made to reduce the free oxygen from 8 cc. to 2 cc. per liter and the residual oxygen is rapidly fixed in the presence of the scrap steel. Water after such treatment is inactive toward iron and may be used without corrosion.

In his paper Mr. Speller gives some discussion to the corrosion of non-ferrous metals and says regarding the rate of corrosion that this "may be retarded by increasing the proportion of hydroxyl ions with relation to the hydrogen ions present in the water. In practice, in the case of boiler water, this can be carried out by the use of 5 to 10 grams per gallon of hydroxide alkalinity but with domestic water it is possible to use only a comparatively small amount of alkali and the protection afforded is proportionately lessened." Great Lakes water with about 8 grams per gallon of calcium carbonate is very much less corrosive than New York City water with one or two grams per gallon of carbonates although each have about the same amount of oxygen.

Anaphylaxia: Its Role and Its Treatment*

A Study of Poisons that Make the Victim More Sensitive to a Second Dose

By Charles Richet

LET me recall in a few words the principle involved in the phenomenon of anaphylaxia discovered by me in 1902:

If any toxic colloidal substance, a fatal dose of which has been previously determined, be injected into the circulatory system of the body, it is found that those animals which have been capable of resisting death—*i.e.*, who have received a dose not quite sufficient to be fatal—have become so sensitive to the action of the poison in question that they will die from the effects of a new injection, even though the dose in the latter be only one-tenth as great as the original dose. Sometimes, indeed, a dose only one hundredth part as great as the dose ordinarily fatal will suffice to cause death from this second injection. This disturbance is known as the anaphylactic shock.

Thus, a special condition of hyper-sensibility in the organism has been created by the original dose. It has always been known that the state of being *accustomed to the poison*, a state often termed *mithridatism*, would enable the organism, thanks to its habituation to the poison, to support doses of increasing strength. Morphine addicts, for example, are capable of ingesting doses of morphine one hundred times as great as normal individuals can do.

From the point of view of general biology and of the defence mechanisms and organisms, we well understand that phenomenon of habituation which increases the resistance to poisons of the body. But we do not comprehend at all how this state of anaphylaxia can be useful to living creatures, since this state creates in them an actual inferiority, because of the fact that this hyper-sensibility makes them less resistant to toxic action.

And yet we can scarcely suppose that there are for living creatures conditions unfavorable to their resistance. Up to the present time all that we have learned with respect to the adaptation of living creatures to the medium in which they live, through a change in the properties of their tissues is, that the power of resistance undergoes an increase. Hence anaphylaxia in which state a diminished resistance is exhibited is a sort of biological paradox which is well worth while to examine with attention.

It is evident that the biological utility of anaphylaxia cannot be established by experimental facts. Only theoretical ideas are capable of doing this, but in such a case as this hypotheses are quite legitimate when they are based upon positive experiments, and when they succeed in disposing of the singular anomaly here involved, which would be almost unique in the field of general biology, of a property belonging to living creatures which is unfavorable to the life of the individual or of the species.

It is my purpose, therefore, to present in these pages what seems to me the most rational explanation of the matter. But in order that the reader may better comprehend what I am about to say, it is advisable that I should enter into certain details with respect to the effect produced by and upon the poisons introduced into a living body.

There are two kinds of substances—toxic and non-toxic—which may succeed in penetrating the blood. These may be classified as *colloids* on the one hand, and as *crystalloids* on the other.

The latter are substances which are capable of being crystallized, which are soluble and which are able to pass through membranes. Examples of these include metallic salts, sugar, urea, and alkaloids, all of which have this common property of being more or less readily diffusible. When these bodies are injected into the blood they are highly toxic in some cases and very slightly so in others. But whether they be toxic or not, whether they be as harmless as common salt or as hypertoxid as the sulphate of atropine, they are *incapable of accumulating in the blood.* This is because they are at once eliminated either by the lungs, if they are gaseous, or by the kidneys if they are soluble.

No crystalloid poison produces the phenomena of anaphylaxia.

Because of this fact we are at once led to conclude that these poisons fail to exert an anaphylactic effect because they are incapable of accumulating in the blood. And we are further led to formulate the following law which forms the expression of a very general fact:

Poisons which do not accumulate in the blood do not cause anaphylaxia.

If there is habituation in certain cases even though we do not clearly grasp the mechanism by which the body has thus become accustomed to the substance in question, it is because all living cells have this power of supporting stronger and stronger doses of any given poison. I have succeeded in accustoming the lactic ferment to live in solutions of thallium nitrate, of sodium arseniate or of potassium bromide, five times as strong as the solutions ordinarily compatible with the life of the organisms which compose the normal lactic ferment. Just as we see that addicts of morphine can support without dying injections of as much as two or three grams of the chloro-hydrate of morphine, so we observe that this lactic ferment, provided it has first been subjected to a process of habituation, is able to live in solutions of the nitrate of thallium, which are eight times as strong as the solutions in which non-habituated lactic ferment can exist.

But at any rate among the higher vertibrates, if there be habituation there is no accumulation because of the fact that the ingested morphine is eliminated by the kidneys.

NON-ELIMINATION OF COLLOIDS

But it has been proved by definite experiment that inorder crystalloids, colloids fail to be eliminated. Colloids have properties very different from those of crystalloids: they cannot be crystallized and they do not pass through membranes and as a result they cannot be eliminated from the body. Hence the reaction exhibited by the organism, *i.e.*, the resistance to colloid poisons shown by the body, must be according to entirely different methods.

When a concentrated solution of chloride of sodium is ejected into the body, the latter at once begins to defend itself against this substance which has become toxic through being present in excess by a very simple process, namely: by elimination through the kidneys. After the injection of 20 grams of common salt this excess is eliminated within the space of an hour at most, and the blood is found to have returned to the *statu quo ante.* But when the toxic substance in question is a colloid, elimination by means of the kidneys becomes impossible and the poisonous material cannot be eliminated either through the kidneys or the lungs.

But it has been proved by definite experiment that in order to rid itself of a poison which it is incapable of excreting the organism proceeds, by a truly marvelous adaptation, to manufacture a counter-poison, *i.e.*, an *anti-toxin.* This was proved by Behring in 1892, when he repeated the experiments made by me in 1887 with respect to sero-therapy. He discovered what I did not perceive in 1887, that there is a production of anti-toxins (diphtheric and tetanic) after the toxins of diph-

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theria or tetanus have been injected. I had showed in 1887 that the blood possesses an anti-toxic potency, but I had not been able to detect the cause of this power; this was accomplished four years later by Behring.

It ensues that after the injection of the toxic substance a state of *immunity* is produced in certain cases, *i.e.*, the body exhibits an increased resistance to the poison. This is the general method of defense against the ingestion of a colloidal poison.

THE CAUSE OF ANAPHYLAXIA

But in order to explain the phenomena of anaphylaxia we must have recourse to another idea: we must assume that there appears in the blood another substance whose function it is to reinforce the poison. I have not been able to isolate this substance, but I have given it the name of *toxogenin* (it is termed also *anaphylotoxin* by Friedberger and sensibilimogen by Besredka).

Hence we see that the organism possesses two methods of defense against penetration by colloids and by toxins: it produces *anti-toxins* on the one hand, and a *toxogenin* on the other.

Why, then, from the *finalist* point of view with which we are here concerned, is a toxogenin produced, *i.e.*, a substance whose office is to reinforce the deleterious effects of the poison? for, when an animal has been anaphylactised, even a small dose of the toxin—sometimes only a hundredth part of the usual fatal dose—overwhelmingly disastrous effects are produced. In the space of less than a minute the anaphylactised dog falls to the ground unconscious, with difficult respiration, with a heart beating at first tumultuously and then very feebly, and with a cessation of the circulation of the blood; with a severe congestion of the entire intestinal apparatus, with a profuse bloody diarrhœa, with violent and uncheckable vomiting, with a mental and a lamentable exhibition of agonized suffering, so that it often seems as if the animal is about to die—and, indeed, it often happens that the animal does die within a few minutes from this terrific anaphylactic shock.

The following experiment is very well fitted for the purpose of showing the degree to which anaphylaxia and immunity may co-exist and even coincide: from a Brazilian plant called the *Hura crepitans* I have extracted a toxic albumen to which I have given the name of *crepitine*. This substance possesses exceedingly curious biological properties. When administered to an animal no poisonous effect is at first apparent, but at the end of ten or fifteen days every dog in whose veins it had been injected was dead.

Assuming the toxic dose to be 1 gram (an amount which is fatal in 15 days), one-half a gram may be injected without producing any immediate effect upon the animal to all appearances; 25 grams must be injected in order to cause immediate death. After having the first amount injected the animal appeared slightly ill at the end of 15 days; but at the end of a month it had apparently returned to its original condition, although it was a little bit thin. *Thus the animal was anaphylactized and immunized at one and the same time.*

I proved this to be the case in the following manner. One month after the first injection of 0.5 gr. I injected in this dog a dose of 1 gram, which is fatal for a normal dog, but which does not kill the animal till 15 days have elapsed. Within the space of a minute the anaphylactized animal fell to the ground lying upon its side in an almost dying condition. For several minutes I was not sure, indeed, whether it would survive. It did, however, recover, being almost normal at the end of 15 days. The normal dog, on the other hand, which has received for the first time this dose of 1 gr. of crepitine shows no effect at the moment of the injection, but during the days which follow it begins to fail in health, so that it dies on the fifteenth day. The lessons to be drawn from these results are first, that *the animal was not anaphylactized*—hence no immediate effects were exhibited; and second, *it was not immunized*—hence it was not able to resist the fatal dose injected later.

FINALITY

Let us now try to interpret this experiment, keeping always in mind its relation to finalism.

It is above all important with respect to the resistance to poisons presented by living creatures, that as soon as the first sign of a given poison shows itself, a violent symptom should be exhibited, *e.g.*, by an abrupt and vigorous reaction which will prevent the continuation of the toxic action. If the organism starts to defend itself at the very beginning then the injection cannot be continued. Through anaphylaxia the organism has been put on its guard. Warned by a first intoxication the nervous system has become so sensitive that it will defend itself with vigor against a second intoxication.

But we must go still further in the direction of finality, for thus far we might suppose that the colloid injected in a dose of inoffensive amount may have remained in the organism without causing the production either of a toxogenin or of an anti-toxin. For example, when a foreign serum is injected it produces no ill-effect, provided the dose is not too strong. Thus, 2 cubic centimeters of horse serum can be injected in a small guinea pig without harmful results. But this injection of horse serum, however, occasions very intense anaphylactic effects—effects quite unexpected, since a hundredth part of a cubic centimeter of the same serum injected in the same guinea pig three weeks later will cause its instant death.

It is evident that in this case the organism was tremendously sensitized. What is the reason for this? What is the object of this extraordinary property in our tissues?

The following hypothesis appears to give an answer to these questions:

The composition of the blood has been altered through its invasion of a foreign colloid, and as a result of this the chemical constitution of the guinea pig's blood has been modified. This modification is an actual attack upon the biologico-chemical stability of the guinea pig species.

But if it be true that certain general laws govern the life of animals it is of first importance that these must persist with quite definite specific characters. In spite of all the various forces which tend to transform these, in spite of the various mediums which form their environment, they exhibit an almost irresistible tendency to remain the same in spite of all external influences. It is true that in spite of this law mutations sometimes occur, but these are produced seldom and with difficulty. A very lengthy effort is required on the part of external forces to produce in individuals modifications sufficiently stable to be transmitted to its descendants. Even if there be an occasional hereditary transmission of a mutation, there is an almost inevitable return to the normal. Nature appears to have willed it that each species should remain invariable. Everything happens as if Time had ceased to exist. The guinea pig species and the horse species, for example, must pursue their existence during a long series of identical generations.

The stability of species appears to be the law of nature.

We are justified in ascribing intent to natural forces for this opinion is the result of innumerable and incontestable observations. These are facts and it is our right to give a general application to these facts by saying that everything happens as if the stability of species was one of the definite objects of Nature.

Since this is true the introduction into the blood of foreign substances capable of remaining there without being eliminated, and which as a result of this might finally form a part of the chemical constitution of the creatures in question, forms a grave peril to the stability of the species. A guinea pig having 1 per cent of horse blood in its blood would no longer be an entirely normal guinea pig. As a result of this it is essential to the stability of the species that the accident which introduced a foreign element into the body of the guinea pig should

not be repeated. In other words, this 1 per cent of horse blood is quite innocent in itself, but it must be prevented from being repeated, for at the end of a hundred successive injections we should have a guinea pig whose blood would be identical with the blood of the horse.

Hence we see that *anaphylaxia is a method of defence for the species rather than for the individual.* It is immunization which forms the process of defence in the case of the individual, but it is anaphylaxia which comes into play to maintain the fixity of the species. But we are well aware that nature seems to care but little for individuals and that her great preoccupation is the keeping stable of the life of the species from generation to generation.

This concept of the rôle belonging to anaphylaxia is evidently pure theory—nevertheless it is perfectly admissible for we can scarcely permit ourselves to believe that there can be any general organic tendency which is quite useless to the species—and even less can we believe that there exists a tendency which is actually harmful either to the individual or to the species.

ANTI-ANAPHYLACTIC TREATMENT

Recent efforts of medical men have been directed toward combating the anaphylactic effects described. The theory first advanced by the well-known French scientist Portier and Ch. Richet was that the disturbance in question was due to the production of a poison to which the name of ato-toxin was given, and acting upon this theory an attempt was made to lessen the supposed toxicity of serums either by heat or by chemical means. The results thus obtained, however, were either uncertain or inadequate.

Besredka's Discovery.—In 1907 Besredka begun a series of experiments by means of which he discovered that an animal which has been *sensitized, i.e.*, one which has received a first injection of the anaphylactic substance, can be protected from the shock which commonly follows the second injection, if previous to the second injection a small quantity of the same substance, *i.e.*, of the *antigene* be injected. Since making this discovery Besredka has improved his process by making use of the method known as *subentrant* injection. This method consists in making three or four preventive injections instead of a single one at intervals of a few minutes, the quantity of serum employed being slightly increased at each injection. In this manner the patient is made to acquire an anti-*anaphylactic condition* which enables him to receive doses of the same serum without shock which might otherwise prove dangerous or even fatal.

Besredka offers an interesting hypothesis to explain this result. He believes that the successive injections of the antigene progressively neutralize the poison by producing a series of very small shocks or disturbances, each of which is so light as to be practically imperceptible, yet whose combined effect is sufficient to neutralize the antibody (*i.e.*, the poison producing substance), so that the patient is restored, so to say, to a "fresh" state.

This concept of the matter which, as we have said, was inspired by Richet's chemical theory and which assumes a narrowly specific character of both the antigene and the antibody, is contradicted by various facts according to Dr. J. Laumonier, who discusses the matter in *Larousse Mensuel* (Paris) for May, 1921. According to this authority both Roux and Besredka himself have found that certain narcotic substances, such as ether, alcohol, etc., prevent the production of the shock in sensitized animals, because, as they suppose, the state of narcosis makes it impossible for the nervous system to react and produce the characteristic phenomena of the anaphylactic shock. But this explanation, likewise, finds critics. Kopaczewski obtained the same preventive action with aqueous solutions of chloroform and of ether which were so weak as to be absolutely incapable of producing anesthesia. But even before this Friedberger had succeeded in preventing the shock by the simple injection of salt water; Billard and others had done the same thing by the injection of certain mineral waters employed in an emergency; Kopaczewski and Vahram by injections of oleate of soda; and Kopaczewski and Roffo by injections of bicarbonate of soda.

In 1919 Richet, Brodin and Saint Girous found that the second injection of serum became harmless if diluted with 9 times its weight of physiologic salt solution; in 1920 Lumière and Chevrotier, attributing anaphylactic disturbances to the formation of a precipitate in the bodily humors of the sensitized subject, discovered that the hyposulphite of soda prevents this precipitation and thus destroys the ill effects of the second injection.

From all these facts and others which might be cited it is clear that the anti-anaphylactic action does not depend upon a *chemical* combination, and is consequently not *specific* in character, since the most various substances are capable of producing it.

Hence we are impelled to seek a *physical* explanation, *i.e.*, one dependent not upon chemical affinity, but upon the physical properties of the humors of the body and of the substances introduced therein, and particularly those properties which are connected with the colloidal state, absorption and multiplication of the surface of contact, electric charge, superficial tension, viscosity, osmotic power, etc. From this point of view the concept of Danysz is more satisfactory, in spite of the fact that it is formulated in chemical language.

It is his belief that the anaphylactic poison is not formed until the antigene of the antibody is present in certain proportions; this is why a certain length of time is required for the introduction of the antigene (the first or preparatory injection) to produce a sufficient number of antibodies. If, when this amount is arrived at, a new dose of the antigene is injected in the quantity desired, there is a formation of poison, whose pressure is betrayed by the anaphylactic shock. But if, instead of the full amount of the desired dose one or more weaker doses are injected, there is no longer a balance between the antigene and the antibodies; the poison is not formed, and not only is there no shock, but the subject is desensitized once more. In other words, expressed in terms of physics, any substance (the antigene) capable of disturbing the equilibrium of the colloid of the serum or of the bodily humors of the subject, produces an immediate reaction (the hemoclasic crisis, or colloidoclasia of Widal) whenever there is a great difference of structure between the serum and the body injected, such as microbes, colloidal metals, sugar, alkaloids, arseno-benzols; and a very different reaction, on the other hand, if the difference is comparatively slight, as when therapeutic serums, extracts of organs, or foreign albumens are injected. In the latter case (anaphylaxia), and for the very reason of the structural resemblance of the bodies thus brought together, the modification of the humors is slow, so that the condition of unstable colloidal equilibrium is arrived at only little by little. If at this moment a sufficient dose of the antigene be injected, there is a definite rupture of equilibrium—in other words, a *shock*. But the characteristic features of a physical rupture of equilibrium in colloids, *i.e.*, of their destruction—consist in floculation, agglutination, and precipitation.

In order to avoid shock, therefore, in a sensitized subject (whose colloids are in a state of stable equilibrium) the physician should administer either very small doses of the "releasing" body (*i.e.*, the second injection of serum) thus accustoming the organism to rapidly digest and assimilate the precipitate formed, according to the Besredka process; or else he should inject substances capable of acting as stabilizers of colloids, such as alcohol, ether, sodium chloride, and the carbonate or the hydrosulfite of soda, which prevent the formation of the precipitate.

Evidently this *physical* explanation regards only the physical reactions of colloids: electric charge, surface, tension, viscosity, absorption, power of interference and of assimilation, etc., and does not concern itself with the chemical reactions

which doubtless also play a part, but one which is secondary or ulterior because of the small amount of the injected bodies.

But whatever the validity of the theories, which demand further study in practice, the anti-anaphylactic treatment as applied to man is definitely successful . . . since all of the various treatments described above protect the patient from the evil effects of anaphylactic shock.

THE CRADLE OF MANKIND

ONE of the much debated questions of anthropology, ethnology and kindred sciences, is the location of the Garden of Eden, to speak symbolically. In other words, the situation of that part of the world where prehistoric man first began his long climb toward ascendancy over other animals. Modern theories offer various new suggestions which are briefly discussed in the monthly supplement of the *Chemiker-Zeitung* (Berlin) for August 1920. This writer remarks that it is only quite recently that some doubt has been felt with regard to the accuracy of the earlier theories. It is beginning to be a more and more widely accepted view that human beings originated, in all probability, in at least three different points on the globe, though probably during the same geological epoch, i. e., in the Tertiary Period. The very great differences in bodily structure exhibited by mankind have led to the belief expressed by Dr. Klassen in *Kosmos* (Berlin) for June 1920, that mankind is not to be considered as a uniform species, but that white men differ so much, from negroes on the one hand and the Australian races on the other, that they are to be regarded as forming three distinct families.

Robert Koch was led to this same conclusion through his studies of African diseases. Moreover, certain discoveries, especially those made by Horst, Arldt, and Melchers, also support this view of the manifold origin of the human race. These discoveries appear to indicate that there are three main roots each possessed of characteristic marks, such as are today to be observed in the three main divisions of the great Man-like Apes, namely, the Chimpanzees, the Gorillas, and the Orang-Outangs. These characteristics are designated as the Chimpanzoid, the Gorilloid, and the orangoid marks, and they are respectively to be found as regards their original home, in Western Europe, in Western Asia or Southern Asia, and in Eastern Asia.

These same divisions are quite manifest in the various races of human beings. Thus, there are three chief races among mankind, the white Europeans, the black woolly or crinkly haired Africans, and the yellow sleek-haired Asiatics. Of course, during the course of human history there has been every degree of intermixture among these three chief original races, so that today it is scarcely possible, indeed, to find absolutely pure descendants of any one of the original root races in any quarter of the earth. Even among the natives of America modern anthropologists are of the opinion that three root races can be proved to have existed. It is certainly an uncommonly instructive fact that among the American natives there are to be found not only the Ethiopic type and the Mongolian type, but the European type.

THE BODILY HEAT OF YOUNG ANIMALS

SOME very interesting experiments have recently been carried out by a German scientist, Professor Leichtentritt, in the Physiological Institute of the University of Hamburg, with respect to the bodily heat of new-born animals and birds, such as dogs, cats, rats, guinea pigs, fowls, sparrows and thrushes. Tests were made by means of an oxygen respiration apparatus and a sensitive thermometer, and some interesting discoveries were made, especially in regard to the physiological processes in birds. In the case of kittens and guinea pigs the amount of heat appeared to depend upon the strength of the animal, which was conditioned by the number in the litter. Strong animals, weighing from 145 to 190 gr. are born, as a rule, with a fully developed system for heat regulation, and weaker ones weighing less than 100 gr. also show traces of such a system, since, when the temperature of the outer air falls they show an increasing use of oxygen, but one which is insufficient to maintain the heat of the body for a very long time. By the time they are 24 hours old, however, the young creatures were always found to have developed the power of producing heat in the blood to such an extent that in the same degree of temperature they used twice as much oxygen as at first, and when there was a very great fall in temperature the increase of oxygen used was fully 96 per cent more. In the case of small chicks the results were similar. Cockerels, weighing 68 gr. and having a body temperature of 35°C. maintained their temperature until the outer air had cooled down to 19°C., but by the time the thermometer had reached 14°C. the temperature of the blood had fallen to 20°C., without appearing, however, to cause the little creature any discomfort.

Different results were observed in the case of young birds. Young sparrows, whether still quite naked and blind, or whether two weeks old and almost full-fledged, exhibited only a very slight and insignificant increase in the consumption of oxygen upon a fall of temperature from 31°C. to 18°C.—an increase so small that it was not sufficient to maintain the temperature of the blood. Obviously, therefore, the system of heat regulation is much poorer in nestling birds than in mammals and young chickens. When the outer temperature fell to a temperature of from 18°C. to 10°C., i. e., to a temperature which often occurs during the first breeding period, the consumption of oxygen and the temperature of the blood showed a marked decrease; but whereas young kittens and chicks were frozen in the cold until they looked to be dead and it was difficult to restore them by artificial heat, the young sparrows and thrushes bore the same degree of cold with ease.

Hitherto naturalists have been inclined to regard this imperfect heat equilibrium in young birds as a sign, together with the helplessness of the blind and naked little creatures, of a certain degree of imperfection on the part of nature; but now the opposite opinion must be held. Even on fine, warm days it is not an easy matter for the parent birds to get enough food for their brood, while on the cold and rainy days which are so frequent in the spring of the year, the difficulty is, naturally, greatly increased, since on such days insects creep into hiding places and vegetable food is also scarcer and harder to get; on such days, too, the adult birds themselves need more food than usual on account of the cold; but because of the longer absence of the parents from the nest and the consequent cooling off of the young birds, the consumption of oxygen decreases and on this account the young birds' need of food is correspondingly diminished.

But aside from the question of food the apparent imperfection of nature in the helplessness exhibited by young birds works for good, since it notably strengthens the affection between the parents and the offspring and tends to increase their devotion to their home. Professor Leichtentritt has given convincing proofs that all of the motions made by the young sightless birds in taking food, such as the stretching of the neck, the raising of the head, the opening of the beak and the peeping noise they make are reflex imitations, so to say, of the motions made by their elders: the first being occasioned by a comparatively violent shaking of the nest, the second, by the call of the parent, and the third, by the cutting off of the light through the shadow thrown by the parent's body. The proof of this is found in the fact that these three kinds of reflex action can be incited by artificial means, *i.e.*, by shaking the nest, by making a sound similar to that made by the parent bird and by using the hand to throw a shadow—this latter experiment is sometimes performed by extinguishing one of two lighted electric globes. The fact that the young bird gives a feeble or a strong response to the reflex in question may depend upon the comparative fullness or emptiness of its stomach, or upon the warmth or chilliness of the air. In all cases the elder bird is conscious from the behavior of its young ones how greatly dependent they are upon its faithful care, and this strengthens its own fidelity to the nest.

The Marquis of Worcester and the Steam Engine

An Interesting Figure of the Seventeeth Century and the Claims Advanced on His Behalf

By Herbert T. Wade

IN the entire history of invention it is difficult to find a more interesting and picturesque figure than the Marquis of Worcester, for whom with considerable plausibility claims have been and are advanced for the honor of being the inventor of the steam engine. He has left us an interesting volume of description of a number of his inventions, while history and contemporary records tell much of his political activity; yet in the special field where his work was of extraordinary importance there is a surprising lack of detailed and exact information sufficient to enable the technological historian to announce unreservedly whether this English nobleman-inventor was the first to make in practical form a useful application of steam. Nevertheless there are many arguments to be advanced in support of the claim that he was the inventor of the steam engine in the first of its stages, namely, that of fire engines, and the facts on which such a claim is based, in connection with the personality of the inventor as shown in his writings and otherwise, make a record of rather more than mere antiquarian interest.

The Marquis of Worcester, or Edward Somerset to give his family name, was born the first son of the fifth Earl of Worcester in 1601. This was a year before James I. was proclaimed king of England, and taking an intellectual inventory of the period there would be revealed such facts as the birth of Milton in December, 1608, and the death of Shakespeare in 1616. In 1611 the King James version of the Bible was published, while about this time (1618) the system of logarithms known from its inventor, Lord Napier of Scotland, was being introduced. William Harvey was announcing (1616) the circulation of the blood and Sir Hugh Myddleton was developing (1609-1613) the New River to supply London with water from springs in Hertfordshire. Another landmark was the death in 1626 of Lord Bacon.

Known at first as Lord Herbert, Edward Somerset was educated privately at his father's seat, the Castle of Raglan in Monmouthshire, and later traveled extensively in Europe. In the course of his education his attention and tastes turned to geometry and mechanics. It must be recalled that at this time chemistry had not been released from the mystical shackles of the earlier alchemy and that England was sadly deficient in men of engineering and mechanical skill. To secure those competent to handle the various public works and other engineering projects which the development of British civilization and industry demanded to an ever increasing degree, recourse was had to the continent of Europe for qualified workers. Lord Herbert, however, was interested in mathematical studies, not only on the intellectual side, but his mind was inclined to the practical and he early engaged in reducing to practice his many ideas. In 1628 he was fortunate to obtain for the mechanical development of his various experiments and inventions one Caspar Kaltoff, a German mechanician whom he described as an "unparalleled workman both for trust and skill." Without doubt this worker was established in what was for that time a well-equipped laboratory or workshop and contributed to his master's success. At Raglan Castle it was possible to develop a succession of inventions of consequence and otherwise, ranging from merely amusing toys and automata, devices for making correspondence secret, etc., to ordnance and mechanical apparatus of possible importance and value. These inventions of course included at least one machine for perpetual motion, constructed some time between 1638 and 1641 and exhibited before Charles I. and other notables at the Tower. This machine was of the familiar type having balls attached to the periphery of a rotating wheel.

On account of his friendship for the King and service with the Royalist forces, the inventor suffered serious reverses and was forced to go to France as a voluntary exile, returning to England in 1651 only to be apprehended and confined in the Tower of London, where until 1654 or 1655 he was in more or less close custody. During this interval his mind was active; in fact, as in the case of other reputed inventors of the steam engine, tradition, without the slightest foundation, ascribes to him the familiar experience of watching the vibrating lid of a boiling pot and thereby receiving his realization of the force of steam. This phenomenon Lord Bacon refers to in his essay on the Origin of Invention. In 1655 the Marquis, (his title of Earl of Glamorgan from Charles I. was now repudiated) prepared in manuscript form that interesting record and description of his inventions under title of the "Century of Inventions." On his release from confinement in the same year he began an active campaign to develop and introduce his water-commanding engine, in which he had unbounded hopes. He sought to purchase land and buildings at Vauxhall for further development of this machine or apparatus, it being very likely that this site previously had been the scene of various engineering and ordnance undertakings in which the Marquis may have had a part. His projects and schemes for the water-commanding engine figure, though without satisfactory mechanical details, in many documents of the period, the most notable one dating to 1663, when Parliament passed an act giving to the Marquis and his heirs for 99 years a patent for his water-commanding engine. With such frequent reference to this invention it is natural for the reader to expect some full description of it, even from the slight details available and the fragments which antiquarians have pieced together almost in the way of circumstantial evidence. Thus in 1664 M. Sorbiere, historian to the King of France, in a small work published in Paris entitled "Relation d'un Voyage en Angleterre," etc., says:

"One of the most curious things I wished to see was a Hydraulic Machine, which the Marquis of Worcester has invented, and of which he has made experiment. I went expressly to Vauxhall, the other side of the Thames, a little below Lambeth, which is the Palace of the Archbishop of Canterbury, in sight of London. The machine will raise to the height of 40 feet by the strength of one man, and in the space of one minute of time, four large buckets of water, and that by a pipe or tube of 8 inches." Another reference, but rather contemptuous in nature, is that in which Dr. Robert Hooks, in a letter of 1667 to Robert Boyle, refers to the Marquis of Worcester's water-commanding engine, styling it after an examination as "one of the perpetual motion fallacies."

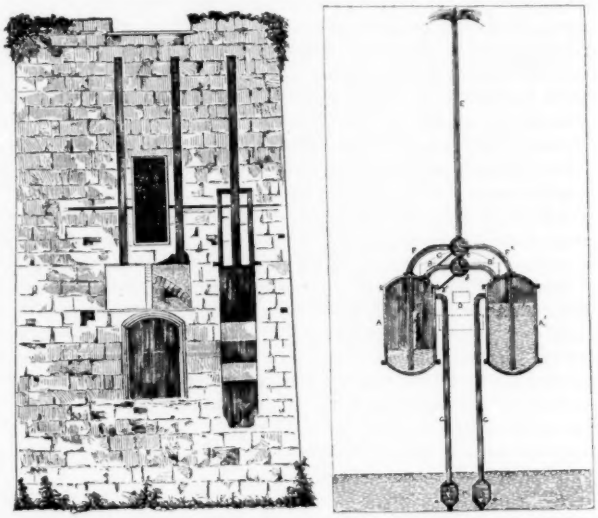
Further evidence of an eye witness is to be found in the Travels of Cosmo de Medici the Third, Grand Duke of Tuscany, who visited England and on May 25, 1669, "went to see an hydraulic machine upon a wooden tower in the neighborhood of Somerset House which is used for conveying water of the river to the greater part of the city." And on the 29th of the same month it was also recorded that "His Highness, that he might not lose the day uselessly, went again after dinner to the other side of the city, extending his excursion as far as Vauxhall, beyond the palace of the Archbishop of Canterbury, to see an hydraulic machine, invented by my Lord Somerset, Marquis of Worcester. It raises water more than forty geometrical feet by the power of one man only; and in a very short space of time will draw up four vessels of water through a tube or channel not more than a span in width; on which account it is considered to be of greater service to the public than the other machine near Somerset

House." This all is interesting in that the Marquis of Worcester had died on April 3, 1667, and his water-commanding engine doubtless was in operation from 1663 to 1670. But still the reader has not been informed as to its nature. The Marquis in his "Century of Inventions," Article 68, informs us of "An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upward." He states further: "I have seen the water run like a constant Fountaine-streame forty foot high; one Vessel of water rarefied by fire driveth up forty of cold water. And a man that tends the work is but to turn two Cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim between the necessity of turning the said Cocks." Then again in Article 98 the Marquis refers to "An Engine so contrived, that working the Primum Mobile forward or backward, upward or downward, circularly or cornerwise, to and fro, streight, upright or downright, yet the pretended Operation continueth and advanceth none of the motions abovementioned, hindering, much less stopping the other; unanimously, and with harmony agreeing they all augment and contribute strength unto the intended work and operation: And therefore I call this a *Semi-omnipotent Engine*, and do intend that a Model thereof be buried with me." But no such model ever was found when the tomb years after was opened with this object, and the description which certain enthusiasts interpret as meaning a piston engine finds no support either in contemporary record or history. Finally in Articles 99 and 100 the Marquis refers with enthusiasm to a device to raise weights based on the principle of the condensation of steam and a water work or pump, where "A child's force bringeth up an hundred foot high an incredible quantity of water, even two foot Diameter, so naturally, that the work will not be heard even into the next room; and with so great ease and geometrical Symmetry, that though it work day and night from one end of the year to the other, it will not require forty shillings reparation to the whole engine, nor hinder one's day-work." And then with the modesty, "I may boldly call it *'The most stupendous work in the whole world'*; not only with little charge to drain all sorts of mines, and furnish cities with water, though never so high seated, as well as to keep them sweet, running through several streets, and so performing the work of Scavengers as well as furnishing the Inhabitants with sufficient water for their private occasions; but likewise supplying Rivers with sufficient to maintaine and make them portable from Towne to Towne, and for the bettering of Lands all the way it runs; with many more advantageous, and yet greater effects of Profit, Admiration, and Consequence."

Now while the descriptions, of which the foregoing are extracts, hardly warrant the promise of the author of the "Century" that the volume contains only those inventions he can call to mind to have "tried and perfected," yet taken with other data they enable the enthusiastic though partisan biographer of the Marquis of Worcester, Henry Dircks, to reconstruct the original water-commanding engine, at least to his own satisfaction, and to base thereon a claim for the invention of the steam engine. His sectional drawings, he asserts, meet the conditions of the description, and with such apparatus water could be raised to a vessel or reservoir through condensation, and then forced to a further distance above simply by turning the valves by hand and keeping the furnace fire burning. The method will appear from Dirck's description of his diagram.

With this reconstruction, which embodies all the various elements and descriptions, we can go back to the days at Ragland Castle before the "Century" was published, and after a consideration of the ruins presume that such a water-commanding engine was here installed. Evidence in support of this theory was sought in the remains of the castle citadel or keep where certain mysterious grooves were found and assumed to house the pipes and reservoirs of such an engine, where the heat from burning fuel produced steam in a vessel or boiler containing water, which in turn acted to drive water through vertical pipes to a considerable elevation, presumably a large cistern on the summit of the citadel. The accompanying illustration shows the walls of the citadel with the grooves and cells in which such an assembly of boilers, pipes and reservoirs might have been installed. To Dircks the evidence of the ruins and the records and fragments seem clearly to demonstrate the first practical application in a primitive form of a means of employing steam as a useful mechanical agent and thus placing the Marquis of Worcester in the position of being the inventor of the steam engine. But in the same way we might go back to before the Christian era and consider the Aeolipile as the first useful application, or such predecessors of James Watt as De Caus (1615) with his hot water fountain, Branca (1629) with his steam jet driving a small mill, Savery (1700) with his engine to raise water, etc.

It is of passing interest to refer briefly to some of the



THE "WATER-COMMANDING ENGINE" AS RECONSTRUCTED BY DIRCKS, AND THE FACE OF RAGLAN CASTLE, SHOWING THE MARKS THAT ARE CLAIMED TO INDICATE ITS INSTALLATION THERE

DIRCKS EXPLAINS HIS DRAWING AS FOLLOWS:

A,A′ are two cold-water vessels connected by B,B′, the steam pipe, with C, the boiler, set in D, the furnace. The cold-water vessels A,A′ also are connected with E, the vertical water pipe, by means of F,F′, continuations of the same pipe conducted into and nearly touching the bottom of each vessel A,A′. G,G′ are two water supply pipes, with valves a, a′ dipping into .H, the well. It is obvious by uniting these pipes, and placing the valves in the upper bend of each, it would be sufficient for a single pipe to dip into the water to be raised. On the steam pipe BB′ is *b*, a four-way steam cock operated by *b′*, its lever handle; and on the horizontal portion of the water pipe FF′, is *c*, a four-way water cock, operated by *c′*, its lever handle.

other inventions made by the Marquis and duly described in his "Century of Inventions," which is a remarkable commentary not only on his personal characteristics and tastes but on the times in which he lived. Here was a period when mechanical curiosities were considered a favorite pastime of the intellectuals. The Marquis used the term inventions rather loosely, as many of the devices or methods he set down as original he had seen in the course of his travels or perhaps were common practice of the time, as, for example, a system of shorthand, of which he wrote several kinds as well as different forms of ciphers. But the Marquis was broad in his tastes, even if many of his descriptions deal merely with mechanical toys without practical application, and it is interesting to examine even the classification of this extraordinary collection. Of the various inventions 3 refer to seals and watches, 2 to games, 2 to arithmetic and perspective, 6 to automata, 23

to correspondence, ciphers, and signals, 10 to domestic affairs, 9 to mechanical appliances, 32 to naval and military affairs, and 13 to hydraulics and the water-commanding engine. Some of the devices described rather test one's credulity, as in No. 77 he tells "How to make a man fly; which I have tried with a little Boy of ten years old in a Barn, from one end to the other on a Hay-mow." Several of these inventions were demonstrated before the king.

It must be realized in this as in other connections, that the times of the Civil War and Restoration were not favorable to the keeping of orderly records. But there is little evidence to indicate that the Marquis of Worcester had, as he said in his preface, "tried and perfected" as many of the inventions as he claimed. To him, however, invention was indeed a pleasure and a passion, for as he wrote in the "Century" Dedication, "The more that you shall be pleased to make use of my inventions, the more inventive shall you ever find me, one invention begetting still another." Such was the picturesque character for whom the invention of the steam engine is claimed. It is doubtful if further antiquarian research can do more to substantiate his title, and while one cannot avoid a certain skepticism, yet there is undeniably a fascination and sympathy with the work of this scientific nobleman, who with better fortunes would unquestionably have made good some of his hopes and aspirations to replace human or animal power with the giant force of steam.

THE OPPAU PLANT

THE quest for new sources of nitrogen, one of the most important, world-wide technical problems of the day, has led to the development of a very remarkable plant in the little village of Oppau on the Rhine in Germany. It was this plant that furnished Germany the nitrogen required for fertilizing the land and manufacturing explosives during the war. It was practically the *sine qua non* of Germany's existence as a belligerent, and now it has made Germany practically independent of Chilean nitrate as far as the requirements of her peaceful industries and enterprises are concerned.

Chile, as is well known, is the only commercial source of nitrate, and while her deposits of this all-important chemical are not nearly exhausted, nevertheless, the world has chafed against her peculiar monopoly and technologists long ago sought to find other sources of this commodity. The manufacture of nitrogen from the air has been carried on on an industrial scale successfully in this plant in the little village of Oppau.

There, the process, known as the Haber process, is being exploited. This process relates to the making of ammonia from the nitrogen in the air, and the subsequent oxidation of it to nitric acid. The plant is owned by the well-known dyestuffs concern, The Badische Aniline und Soda Fabrik. The plant can make 300 tons of ammonia a day, which is equivalent to 1,100 tons of ammonia sulphate.

The nitrogen that is required in the manufacture comes from the air, and the hydrogen, the other constituent of ammonia, whose manufacture has always been a very difficult problem to solve technically, has been produced successfully from a mixture of water gas and producer gas by a catalytic process. The gases were made not from coal but lignite. In the course of this manufacture a tar was recovered which was worked up afterward into a lubricating oil. This oil was used throughout the entire plant and gave very satisfactory results.

The various processes used in the plant are very intricate and require supervision by technically-trained men. After the nitrogen and the hydrogen are obtained in a very pure state, then they are catalyzed into ammonia at a high temperature and low pressure. The French chemist, Claude, has developed a process where pressures of many atmospheres are used. The ammonia is then oxidized to nitric acid with an efficiency of 80 per cent. The plant can oxidize 180 to 200 tons of ammonia a day. The nitric acid is concentrated by mixing it with sulphuric acid and denitrating the mixture in a tower. Ammonia sulphate, for fertilizer purposes, is made from gypsum and ammonia liquor. The capacity of this plant is 1,600 tons of gypsum a day. In addition, ammonium chloride and Solvay soda are also produced. The ammonia and the weak nitric acid are made into ammonium nitrate for use in explosives.

The plant construction was commenced in 1912. It covers 2,000 acres and cost about 18 million dollars on the pre-war rates of exchange. It employs 5,000 men of which 2,000 are in the shops. There are 60 engineers and 500 technical superintendents and foremen.

MOLECULAR STRUCTURE IN FIBROUS MATERIALS

DR. R. O. HERZOG AND WILLI JANCKE.

M. v. LAUE, Friedrich and Knipping demonstrated the fact in 1912 that a bundle of X rays allowed to pass through a crystal and fall upon a photographic plate placed behind the latter, formed points upon the sensitive plate giving indications of the position of the atoms in the crystal, arranged in the form of a space lattice. This discovery was of the most basic importance with regard to our knowledge of solid bodies. Somewhat later the two Braggs, father and son, suggested another method, while the third was proposed by Debye and Scherrer (see *Umschau*, 1920, Bo. 34). These methods made it possible to examine a very finely pulverized substance in order to determine whether the powder had been made from a crystal or from an amorphous body.

More recently we have applied these methods to the examination of fibrous materials (see *Berichten d. deutsch. Chem. Gesell.*) (Reports of the German Chemical Society, page 2162, 1920.) With this purpose, cotton, for example, was torn apart, compressed into a small rod and an X ray was passed through it. If the reflected radiation be received upon a film bent into the form of a circle, there will be obtained, just as in the case of a powdered crystal, blackened lines, sections of the film with circular spherical balls which, starting from the *fibers, surround the X ray. If, on the other hand, the fibers* be laid parallel and the X ray directed upon them vertically, there will be symmetrically arranged points produced upon the photographic plate behind them. From X ray photographs obtained in this manner from cotton, ramie, flax, wood, cellulose, jute and sawdust, it was learned that the cellulose is present in plants in a crystalline condition, and is, likewise, symmetrically arranged along the main axis of the fiber.

An examination of artificial silk shows that this material consists of splinters of crystals, of chemically altered cellulose, connected in irregular chains. Artificial silk made from acetyl cellulose, is amorphous and consists of a mixture in which the acetyl cellulose has undergone extensive decomposition.

Natural silk, on the other hand, exhibits a crystalline character, and possesses a symmetrical structure similar to that of cellulose.

The hair of animals, on the contrary, is amorphous, being apparently built up of two or more different substances.

Starch proved to be crystalline, as was suspected by Naegeli, while glocogen, *i.e.*, starch obtained from the liver of animals, is amorphous. Pure fats are crystalline.

It is of interest to learn from these experiments that the different kinds of cellulose, the different kinds of starches, and the various forms of silk exhibit no difference in the above respect in spite of the most various origin.

This sort of experimental study is merely beginning, but it may be looked forward to to enable us to comprehend the physical properties of various fibers. In this manner such properties as tenacity, behavior with respect to dyes, swelling, shrinking, etc., may probably be explained scientifically through the information obtained as to the physical structure of the fibers, so that eventually they may be controlled by the technological expert.—From *Die Umschau* (Frankfurt a. m.), Jan. 29, 1921.

THE STANDARD DECORATIONS OF THE UNITED STATES ARMY AND NAVY

Left: In order, the Army Medal of Honor, Distinguished Service Medal, and Distinguished Service Cross. *Right*: Corresponding Medals of the Navy, in the same order

"Pomp and Circumstance"

Military and Naval Decorations, Uniforms and Insignia After the War

By Albert A. Hopkins

Author of Our Army and How to Know It—Our Navy and How to Know It, etc.

THE grim memories of the late war are still with us and for generations we shall feel the aftermath of the gigantic struggle. The useful by-product of the war has been small, with the exception of chemical industry, which has come into its own. Of course, the art of war has "improved" if we can call more successful methods of man-killing and man-maiming and ship-sinking an improvement, and all the blood spilled and treasure wasted ought to have brought out many things for the "Art of War." In one small particular the war has made large changes; this is in relation to uniforms, orders, decorations and insignia.

Before the war the uniforms of nearly all nations were gaudy in the extreme imperiling the safety of men in the field, and our own country was quite a sinner in this respect as our pictures of the former army and marine uniforms show. Now all this is changed and the sober olive drab and khaki and forest-green will probably always be in use for everything germane to the practice of the profession of arms.

Insignia suffered enormous changes in the war and we shall duly chronicle some of them which are of far-reaching importance; decorations have also come into their own. Orders have received new significance and under new policies can now be worn by those who have deserved them. This article was prompted by the appearance of a new book on the subject which makes a fitting capstone to the not-too-large-pile of works on the subject. We are referring to a beautiful book just issued by the Putnam's entitled "Orders, Decorations and Insignia, Military and Civil," with a history and romance of their origin by Colonel Robert E. Wyllie of the General Staff of the U. S. A. It is very appropriate that a work of this kind should be written by an army officer who is thoroughly in touch with all phases of the intricate questions involved. This article may be regarded as very largely an illustrated review of this book, although the illustrative material is derived elsewhere, one reason being that many of the illustrations in Colonel Wyllie's book are beautifully executed in full color which would pale to insignificance if reproduced in monochrome. There are twelve color plates in all and their excellence fully warrants the publishers in putting out a book at a relatively high price—a work which contrasts in an amusing manner with the present writer's modest attempt at insignia elucidation, published during the war at a quarter and sold to the number of nearly 200,000.

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UNITED STATES VICTORY MEDAL, WITH ARMY AND NAVY CLASPS, AND A COMPLETE SET OF BARS, OF WHICH NATURALLY FEW MEN HAVE MORE THAN TWO OR THREE

HISTORY OF MILITARY AND NAVAL AWARDS

The author begins at the earliest historical record we possess of medals, which was an award made by an Emperor of China in the first century of the Christian era to his military commanders. There is brief mention of rewards and decorations down the ages, but we do not come to anything very substantial until Tudor times. The modern system seems to have been inaugurated during the reign of Queen Elizabeth, for in 1588 the famous "Ark in Flood" medal was awarded, presumably to commemorate the collapse of the expedition known as the "Spanish Armada." It derives its somewhat curious name from the bay tree in the middle of an inhabited island surrounded by an ocean. The whole is an eloquent exposition of Great Britain's insular position. This was only a naval medal and the army was not considered. Other medals were issued from time to time until 1650, when we find the first medal given to

officers and men indiscriminately. This was voted by Parliament in the time of Cromwell. A distinction was made, however, the officers received gold medals and the men larger medals in silver. These medals sometimes crop up in auctions and sell for about $100. The naval victories over the Dutch in 1653 resulted in several medals, but it was not until 1692 that medals for the rank and file came into being and it was not until 1773 that a general distribution of medals seems to have taken place in isolated instances, with special medals for individual persons, generally the commanding officer. It was the battle of Waterloo that finally broke down the barrier against military caste in the award of medals.

The history of decorations in our own country follows very closely British models, originally only the commanders being honored. The first medal bestowed by our Government was awarded to General George Washington to commemorate the evacuation of Boston by the British in 1776. Captain Paul Jones was similarly rewarded as were the captors of Major Andre. An order was issued from his headquarters at Newburgh on August 7, 1782, by Washington, which calls for a figure in the form of a heart in purple cloth or silk to be worn on the left breast. Colonel Wyllie states that this was our first decoration and the first in history which had a general application to enlisted men. Medals had indeed been given but no decoration for special merit. Although we have lagged behind nations in the matter of decorations we can at least be proud of the fact that our first decoration was a long way in advance of anything then in existence in any country. The War of 1812, the Mexican War and the Civil War all produced medals, although Colonel Wyllie says that at first there seemed a deep seated prejudice in this country against medals and decorations. In 1861 this settled policy was overthrown by the establishment of the Medal of Honor which remained our sole military decoration for nearly forty years. We entered the Spanish War in 1898 without medals and those that had received the Medal of Honor wore them only with full-dress uniforms. The system of wearing ribbons had not then come into vogue. All is now changed and we find uniforms with ribbons of all wars, besides medals and decorations. A false idea of democracy militated against the perfectly legitimate use of such devices, although the free use of decorations by our French sister republic would seem to show that such things were not opposed to democratic and republican institutions. The effect on the morale of troops is enormous and such medals and decorations hurt nobody. The Spanish War broke our spell, as it were, and a few months after the battle of Manila Bay all officers and men who participated in that action received medals. This was followed by other medals; the bars were down and campaign badges and ribbons came into common use.

Wide World Photo

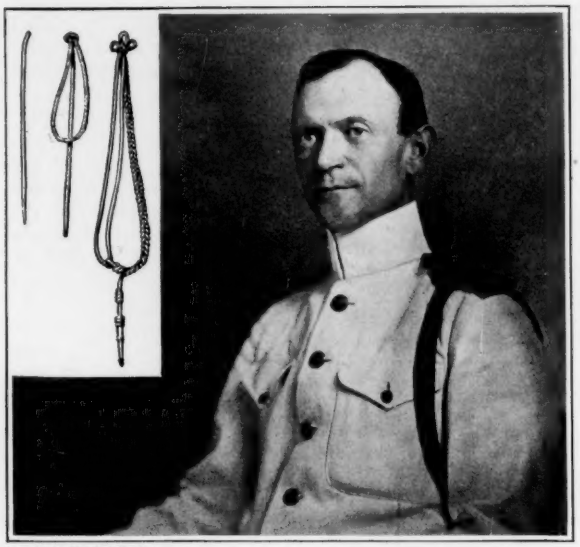
BLANKET MADE BY A FRENCH WOMAN, INTO WHICH ARE WORKED THE SHOULDER MARKS OF MOST OF THE AMERICAN DIVISIONS

WORLD WAR HONORS

Then came the great World War with the heroes of our Allies gaining daily honors. We had nothing which filled the bill; we were hopelessly outclassed at every point by the superior arrangements of other powers. We were hampered with obsolete regulations, such as one which did not allow our officials to receive any rewards or decorations from foreign countries without the permission of Congress. Some of our Allies hinted, gently perhaps, but hinted all the same, that a recession from this position would be a real help to the cause, as it was. An agitation was started and finally, by executive order, the "Distinguished Service Cross" for extraordinary heroism, not calling for the Medal of Honor, and the "Distinguished Service Medal" for specially meritorious service in duties of great responsibility were established. Congress confirmed this action and allowed persons in the Government service to receive decorations and honors from governments with whom we were associated, such permission to expire one year after the close of the war; and the President was authorized to bestow American decorations on members of the military and naval forces of our Allies.

In February, 1919, Congress established two decorations for the Navy: the Distinguished Service Medal, corresponding exactly to that instituted for the Army, as described above, and the Navy Cross, to be awarded for heroism not justifying the award of a Medal of Honor, or for other meritorious service not warranting a Distinguished Service Medal.

The last act in this evolution occurred on the question of the Victory Medal, which is given to commemorate the World War. Heretofore it was our custom to bestow war medals only on those who participated in the campaigns. Those who had the misfortune to remain in the United States received no recognition, even though engaged on work vital to the success of the overseas forces. Soon after the armistice, it became evident that the sentiment of the country was against such a discrimination, and a bill was introduced into Congress to award a medal to all who served in the Army and Navy, regardless of whether or not they had overseas' service. This bill, due to the press of business in the last session of that Congress, never emerged



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THE FOURRAGERE OF THE FRENCH ARMY AND THE AIGUILLETTE OF THE NAVY, AND THE MANNER IN WHICH THEY ARE WORN

FANION OF THE AMERICAN AMBULANCE NO. 5—646 S. S. U. S., SHOWING CROIX DU GUERRE, OTHER MEDALS, AND FOURRAGERES

from the committee, but the principle was accepted by the War Department, and the order establishing the Victory Medal gave it to all who served on active duty during the war, and a system of clasps was adopted to denote participation in battle operations. This custom has been in force in Great Britain since 1813. Under it a much more complete recognition is given for services performed in wars than is possible by a medal alone. The medal itself is given to all who in any way contributed to the military operations, and in addition, clasps are awarded, to be worn on the ribbon above the medal, to show in which battles or campaigns of the war the wearer participated. The medal with its clasps gives a fairly complete record of the service rendered.

MEDALS AND DECORATIONS

"In its broad conception," says Colonel Wyllie, "a medal is a metallic ornament used for commemorative and decorative purposes, usually given as a reward or token. Originally medals were purely commemorative.... but it must not be forgotten that the majority are still struck primarily to commemorate events, therefore the design should be symbolical and artistic. A medalist in addition to being an artist must have imagination, a knowledge of heraldry and both ancient and modern symbolism, in order to produce a design which will be artistic, and at the same time will successfully portray the event in a simple manner. Our War Department is in close touch with the United States Commission of Fine Arts, and for some time that body has assisted in the design of medals and insignia, which insures artistic merit otherwise unobtainable.

"The word decoration is somewhat broader in its meaning than medal as it is not confined to metallic substances, however it has been found necessary to restrict the technical meaning of both these words, and a decoration can be defined as an insignia of honor bestowed for some individual act or service, in contradistinction to a service medal which is for general distribution, commemorative of some war, campaign, or other historical event, to all who honorably participated therein, irrespective of the value of their individual services. For example, a Medal of Honor is a decoration as it is bestowed for some signal act of heroism, but the Victory medal is not, as it is for general distribution to all who served honorably in the World War, it is therefore classed as a service medal. From this it can be seen that a decoration is a higher distinction than a service medal, and takes precedence thereof.

"An 'order' is virtually a society, and the honor conferred on the individual is being made a member of the order or society, so the insignia which is worn is the evidence of such membership; while in the case of a decoration proper it is the insignia itself which is the distinction awarded, there is no official society of the holders of decorations. The countries which have orders place them above decorations in precedence. The principal insignia of an order is called a badge. In addition, that word is applied in the United States to the insignia which are given to show qualifications in marksmanship, aviation, swordsmanship, etc., and also to the insignia of military and other societies. In general therefore the order of precedence places orders first, then decorations, then service medals and lastly the badges which show qualifications and membership in societies.

"The badges and some medals and decoration are made in the form of a cross or star, but the vast majority are circular-shaped like coins, so that a fairly close inspection is required to recognize the distinctions between them. To provide a ready means of identification each has a distinctive ribbon, so that by using different combinations of colors,

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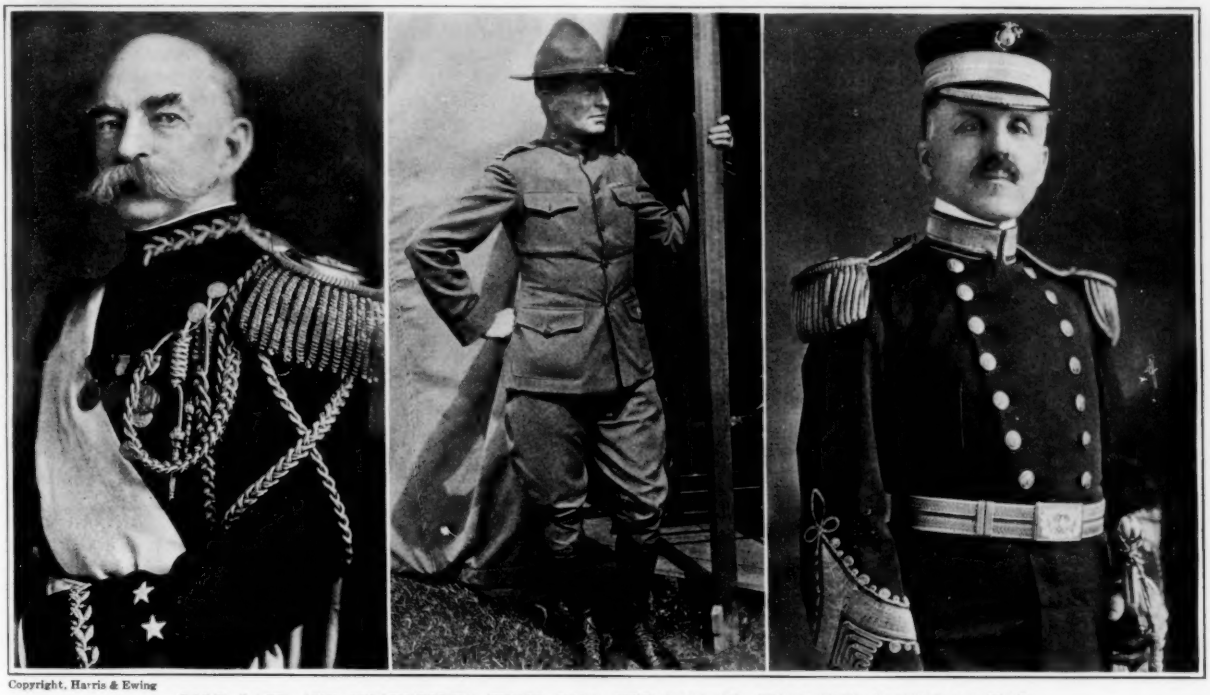
CORRECT WEARING OF DECORATIONS BY CIVILIANS



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GOLD LACE AND EPAULETTES WENT INTO THE DISCARD WITH THE COMING OF WAR

Left: The old full-dress Army uniform. *Center*: The severely practical service uniform worn throughout the war. *Right*: The Marine Corps dress uniform

the particular decoration or medal can easily be identified. This ribbon also serves the purpose of providing a means of suspension for the medal itself, so it is an integral part of the insignia, the medal not being complete without its own distinctive ribbon. Ribbons are not used with the badges which show qualifications in small arms, etc., as those badges are either made in such a shape as to be easily recognized, or they have plain and legible inscriptions indicating exactly the purpose of the badge.

HOW MEDALS AND DECORATIONS ARE WORN

"In uniform it is customary for military men to wear decorations and medals only in full dress; this uniform has recently been abolished for our Army, but the principles still govern, as decorations and medals are now worn only on stated ceremonial occasions, when full dress would have been employed in former days. Even on these occasions the military man is limited to those awarded him by his own, an equal or a superior government; medals of inferior origin are not worn. To illustrate, a soldier of the United States Army, in uniform, should never wear a medal presented to him by a State, municipality, or society, but only those of the Federal Government or a coordinate foreign government. A State officer, on the other hand, can wear a medal presented to him by his own or any other State in addition to those awarded by the United States or a foreign government, but he should not wear a municipal decoration or society badge. This is on the principle that it is derogatory to the dignity of the government whose uniform is worn to ornament it with a decoration emanating from an inferior authority."

Colonel Wyllie then describes service ribbons and lapel buttons:

"Lapel buttons are used with civilian clothes for the same purpose. They are made in a variety of forms, rosettes, bowknots of ribbon, small pieces of ribbon, metallic buttons, buttons in enameled colors, etc., each decoration having its own particular design. Formerly rosettes made of silk ribbon of the same colors as the ribbon of the medal were used by the United States for lapel buttons, but they were not sufficiently distinctive, for example, the army has four medals with red, white and blue ribbons, the navy has the same number in red and blue, and it is impossible to make rosettes in those colors so that the differences can be easily remembered and applied. As a result in 1919 we adopted as a lapel button, a miniature of the service ribbon made in colored enamel. This is now used for all our decorations and medals except the Medal of Honor and the Victory Medal, the former retains its old rosette which is hexagonal and of light blue with thirteen white stars, consequently very distinctive. A colored enamel representation of the rainbow of the Victory ribbon would be difficult if not impossible to make, and the lapel button for that medal is a star on a wreath with 'U. S.' in the center, and is usually called the 'Victory button.'"

Colonel Wyllie makes some excellent remarks about wearing medals on evening clothes, the open front and the lightness of the material militating against the wearing of medals, and miniature reproductions are usually substituted, the scale being one-third to one-half. Of course, the full-sized article and the miniature replica should not be worn simultaneously. On the death of the rightful possessor of a medal or decoration, it should be presented as an heirloom but never worn by any one. Where posthumous honors are given to the next of kin the person holding the same has no right to wear the article.

A "Citation" is an official announcement of appreciation for services performed. It is bestowed in various ways and does not necessarily carry any other reward. Membership in an order is usually conferred in a document called a brevet, which is given to the new member and is the official evidence of his membership. The distinction between award and presentation should be clearly established. A citation which specifically bestows a personal decoration is the award; presentation is when the decoration is actually received. The award is always to the individual who earned the decoration, even though he may have died in the meantime. Whenever possible it is also presented to him and with considerable formality and ceremony, but this is not essential, presentation can occur to any one deputed to receive it. In the case of a Service

Medal the order announcing the qualifications for any particular medal is the award to all who are covered by the order. These medals are rarely presented with formality but are issued to those entitled to them in the most convenient manner.

Medals and decorations, with but few exceptions, are worn on the left breast and in a carefully arranged order of precedence. The place of honor is to the right of the wearer, nearest the center line of the breast, and the highest decoration possessed is worn in that position. Others follow in the correct order of precedence, and then service medals according to the dates of the services rendered. Foreign decorations are worn after all the decorations and medals bestowed by the wearer's government and in the order of the date of receipt. Our Medal of Honor is worn at the neck and it is considered a higher position than on the breast. The service ribbon however is worn on the breast with the others but to the right of them all. When any decoration is worn at the neck the ribbon from which it is suspended is placed around the neck inside the collar so it does not show. With a uniform buttoning up to the neck, the ribbon comes out between the top hooks or buttons, the medal hanging about one inch lower. In evening clothes the medal hangs just below the tie.

OUR DECORATIONS

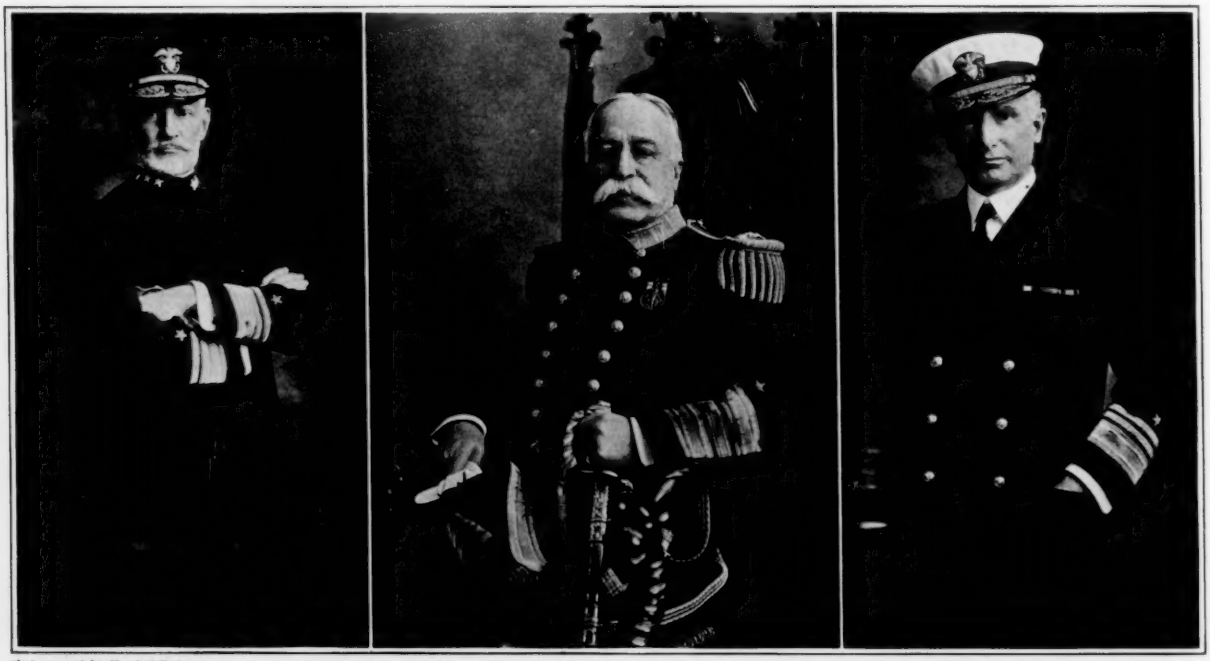
Colonel Wyllie then describes in great detail the history of American decorations including the Medals of Honor, the Distinguished Service Medals, the Distinguished Service Cross. There are two Medals of Honor, one for the army and one for the navy; these are different decorations each governed by different acts of Congress under the same conditions of award, so it is possible for a person of almost medieval bravery to obtain one of each but this situation has never occurred. For a second act warranting a rebestowal of the Medal of Honor *in the same service* a bronze oakleaf cluster is awarded. This is worn on the ribbon of the medal and a miniature thereof on a service ribbon. No case of this kind has occurred and the navy has no device in lieu of a second award. Colonel Wyllie states that there are 1795 on the Medal of Honor roll of the army and of this number 78 were awarded for heroism during the World War—19 were posthumous awards, 58 went to enlisted men, 16 to junior officers and 4 to field officers. Of course, the higher the rank the less chance there is for personal heroism.

The Distinguished Service Medal for the army dates from January, 1918, by executive order and was confirmed by Congress July, 1918. The navy has an identical medal established in 1919. It ranks next to the Medal of Honor and is worn on the left breast to the right of all others. The services need not have been rendered at the front, much less in action, the requirement of great responsibility being the controlling factor. It is our equivalent for the French Legion of Honor. About 1200 of these medals have been awarded, 55 per cent to army officers (including marines serving abroad with the army); 37 per cent to foreign officers; 6 per cent to American and foreign civilians and 2 per cent to U. S. naval officers. The bronze oakleaf cluster is used where a second award is justified.

The Distinguished Service Cross is purely an army decoration and is awarded for "extraordinary acts of heroism in connection with military operations against an armed enemy." Civilians are eligible if they can qualify to the severe rules outlined in the regulations. Bronze oakleaf clusters take the place of the Cross on a second award. Women can receive this decoration if their achievement warrants it. About 5200 crosses were awarded and 95 oakleaf clusters. On this point Colonel Wyllie says:

"Considering the question of rank the observations made with regard to the Medal of Honor are confirmed by this decoration as 72 per cent went to enlisted men, 22 per cent to captains and lieutenants, and only 6 per cent to the higher officers. An analysis of the awards to arms of the service again shows the infantry far ahead of all others, 80 per cent being credited to that branch, then came the Medical Corps with 6 per cent, then the Air Service with 5 per cent, the Artillery 4 per cent, Engineers 3 per cent, the remaining 2 per cent being divided among all other branches."

The Navy Cross was authorized by the same law for those in the naval service and Colonel Wyllie says: "The difference between this and the Distinguished Service Cross of the army should be noted. The army decoration is given only for heroism in war, while the Navy Cross is much broader in scope and in addition to heroism it includes any other distinguished



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NAVY UNIFORMS DEMONSTRATE THE SAME TREND TOWARD SIMPLIFICATION AND GREATER UTILITY

Left: Naval uniform as worn during the war. *Center*: The splendor of the old full-dress line uniform. *Right*: The new type of uniform

service, not only in time of war but also in peace, in the theater of hostilities and elsewhere. When given for heroism it is the equivalent of the Distinguished Service Cross of the army. . . . The three naval decorations cover the whole possible gamut of services which should be rewarded; the Medal of Honor being appropriate for the most extraordinary heroism in action, the Distinguished Service Medal for specially distinguished service in a 'duty of great responsibility,' and the Navy Cross for any meritorious service of whatever character, of a lesser degree."

CERTIFICATES OF MERIT, CITATION STARS AND CITATION CERTIFICATES

The certificate of merit was formerly bestowed on privates and non-commissioned officers, but after seventy-one years it was discontinued in July, 1918, and there is nothing which exactly takes its place. Every officer or enlisted man who is cited in orders for gallantry in action under conditions not warranting the award of a Medal of Honor or a Distinguished Service Cross is entitled to wear a silver star on his ribbon. We find many on Victory Medal ribbons. A citation certificate is a reward of merit issued by the Headquarters of the A.E.F. and signed by General Pershing; it was a stop-gap device and they are not now issued but possessors of them are fortunate.

Colonel Wyllie takes up American Service Medals and Badges, but this does not come within the purview of our subtitle. Then follow chapters on the medals and decorations of Great Britain, France, Belgium, Monaco, Portugal, Italy, Eastern Europe, Asia and our neighbors, Cuba and Panama. We have now concluded with the decoration of persons and we come to the decoration of things.

DECORATING THE COLORS

The history of flags goes back to great antiquity and the subject is too extensive to be even touched upon here except that colors are often decorated as a commemoration of deeds as individuals are decorated for services rendered. Colonel Wyllie says: "In the American and British armies each regiment and other independent unit carries two colors, one being the national flag, the other a flag distinctive of that particular organization, called the regimental or organizational color. In France, Italy and Belgium only one color is carried, the national flag, but certain additions are made to it so that it combines the functions of the national and regimental colors in one."

Let us consider the British system first. Their regimental colors follow no particular plan of design. Each regiment has its own characteristic flag which is different in nearly all particulars from any other. The names of all the important battles in which the regiment has taken part are embroidered on this flag. These are equivalent to the service medals awarded to individuals. The British have no decorations for the colors corresponding to personal decorations for specially distinguished services. The French regimental flag has the national tri-color as a foundation. On one side is the inscription "La République Française," with the designation of the regiment. In the upper and lower corners next the staff are laurel wreaths enclosing the regimental number. On the other side of the flag is the inscription "Honneur Patrie," and under it the names of the four most important battles in which the regiment participated. These again correspond to service medals but the number is limited to four, while the British make no limitation as to numbers. But the French system does not end here. Attached to the staff near the spearhead is the *cravate*, and when a regiment is cited in orders for extraordinary services in action the colors are decorated by attaching a Croix de Guerre to this *cravate*. The cross of the Legion of Honor is used instead when it is desired to show exceptional honor to the regiment. Here we have a decoration of the colors in a manner paralleling the award of a personal decoration to an individual, nor is this all. When a regimental color has been decorated twice a *fourragère* in the colors of the Croix de Guerre (green and red) is authorized as a part of the uniform of the organization, to be worn by every man who belongs to it. The *fourragère* is a cord attached to the left shoulder encircling the arm, and hanging from it is a *ferret* (pencil) of bronze. When the color is decorated four times the *fourragère* is changed to one in the color of the the Médaille Militaire (yellow and green) with silver ferrets, and after six decorations a *fourragère* in the color of the Legion of Honor (scarlet) with gold ferrets, is worn by every man in the organization. When the flag has been decorated nine times a double *fourragère* is worn, the green and red being combined with the scarlet *fourragère;* for twelve such decorations the yellow and green is combined with the scarlet and for fifteen a double *fourragère* of scarlet is worn. It should be clearly understood that the *fourragère* is not a decoration of the individual but of the regiment; it is a part of the uniform authorized to commemorate the heroic deeds of the organization, and a man actually wearing it may never have been in any engagement as he may have joined since the war was ended, nevertheless he wears the *fourragère* as a part of his uniform. It is discarded upon transfer to a regiment not entitled to the *fourragère*, except that a man who participated in all the battles for which the regiment was decorated is entitled to wear it as long as he remains in the service, wherever he is assigned.

INSIGNIA

Insignia is a most fascinating subject and we can safely leave Colonel Wyllie's excellent (though brief) treatment of the subject to the reader of the book itself as it is impossible to translate into cold black and white the vivid colors shown in the four plates devoted to shoulder insignia. We have selected for reproduction a picture which is again far afield from Colonel Wyllie's book. This is a decorative blanket embroidered by a patriotic French woman with the U. S. shoulder insignia *she saw* in France and while not complete it is certainly an impressive collection. A distinctive badge for an army corps is not new for we find it in the Civil War, but the designs were worn on the hat and the same was repeated in the Spanish War. The shoulder decorations of the U. S. forces in the recent war was a common-sense way of solving a difficult problem so that men did not "get lost" either by accident or design. The whole thing was surrounded in more or less mystery and was not a device of the War Department, but it was so very efficient and was so well liked and made for discipline that the military authorities were so won over and a difficult problem for General Headquarters was almost automatically solved so the "wild cat" of the Eighty-first Division was the pioneer. All commanding generals of all combat divisions were directed to select at once insignia for their divisions. A riot of invention follows—the alphabet, numerals, geometry, heraldry, history, ethnology, natural history, botany, astronomy, meteorology and even archeology were all laid under contribution. While the designs varied in excellence the animals seemed to be the most popular and we have polar bears, buffaloes, greyhounds, eagles, cocks, etc. The most appropriate was the lizard of the camouflage corps and the most artistic was the classical head on the shoulder insignia of the Army Artillery School. A collection of these devices will be found interesting long after the sting of the war has lost some of its poignancy. The insignia of rank and branch of profession was also considerably changed and augmented by war.

UNIFORMS

Colonel Wyllie does not go into the question of uniforms beyond the insignia and decorations which now form a part of them but it seemed as though the general subject might be rendered even more interesting by including a few pictures showing full-dress uniforms of the army contrasted with the service uniform in all its severity and as we write the regu-

lations allowing "Mufti" to be worn when off duty by all officers has been promulgated except when not on army post or "engaged in athletics." This is a tacit but valuable indication that actually if not technically the war is over. In the navy for a time the florid uniforms gave way to the simple undress uniforms and contrast that of Admiral Dewey with Admiral Sims' but now full-dress uniforms for certain occasions will be obligatory, but even with this the lessons of the war show that results can be obtained without the elaborate shoulder bars and pipings of a generation ago. Simplicity very largely reigns and "Pomp and Circumstance" has been reduced to its lowest terms.

METHODS FOR DETERMINING SOIL ACIDITY

SALTS of strong acids with strong bases, of strong acids with weak bases, of weak acids with weak bases, calcium hydroxide, the lowering of the freezing point, the catalysis of esters and the hydrogen electrode are all in use in one or another of the various methods advocated for the determination of soil acidity. The results obtained by the different methods show that the condition of a soil at any time can be considered as its progress toward a constantly changing equilibrium according to the principles of Le Chatelier. It is to be remembered that those metalic elements occurring in ordinary soil stand at the top of the electromotive series of elements and that sodium and potassium compounds are all somewhat soluble; whereas many calcium and magnesium compounds and most iron and aluminum compounds are very sparingly soluble in water.

The entirely different results obtained with different salts, and the large variations in soil acidity recently found by Conner when soils were kept at different moisture contents, make it certain that acid soils usually contain many soluble hydrolytic products which are controlled in amount by the quantity of alkaline earths and alkali metals present in the soil.

Carbon dioxide gas has long been known to cause many chemical changes in silicates and phosphates resulting in increased solubility of the constituents of these substances.

Dr. H. A. Noyes presents, in *Science* for June 10, 1921, the following results obtained in recent investigations where soils in culture pots were treated with carbon dioxide.

1. An "alkaline" sandy soil became acid in reaction in three months' treatment with carbon dioxide gas.

2. The acidity of an acid brown silt loam was increased by treating the soil with carbon dioxide gas.

3. Liming this loam decreased its acidity but not as much as the original "lime requirement" determination (Veitch) indicated. One and one-half times the total lime requirement did not neutralize the soil.

4. Where the soil was limed, limed and phosphated, and limed and treated with dried blood or sodium nitrate, carbon dioxide gas additions to the soil increased the soil acidity.

5. The specific conductivity of extracts obtained on treating the soils with conductivity water showed that the carbon dioxide gas had changed the constitution of the soil. The specific conductivity of the dioxide-treated soils was greater.

6. The acidity of the soils was lowered by extraction with conductivity water and the lowering was greater for those samples which had been subjected to the carbon dioxide treatments. A further evidence that the acidity was due to chemical changes in the soil was that the aluminum and iron in the normal potassium nitrate extracts was effected by the carbon dioxide treatments.

7. The volatile material determination was increased by carbon dioxide treatments, and since this increase could not be accounted for in the determination of total carbon, the carbon dioxide gas must have changed the water of constitution of some of the soil silicates.

8. The composition of the conductivity water extracts from the different soils varied as the fertilizer constituents added would theoretically replace substances known to be present in the soil.

9. The composition of the conductivity extracts from the carbon dioxide treated samples showed that the increased specific conductivity and acidities due to carbon dioxide treatment were associated with substances with low solubility and ionization constants present under conditions where hydrolysis readily took place.

In conclusion Dr. Noyes says: The shifting of the acidity, the chemical changes in the soil and the soil extracts were in accordance with the solubilities of salts of metals high in the electromotive series and their tendencies to hydrolize. The work leads to the conclusion that soil acidity is the resultant of hydrolytic mass action phenomena and thus the application of the exact amount of lime shown by any method cannot be expected to give exact neutrality.

SUN SPOTS AND TERRESTRIAL MAGNETIC STORMS

IT has long been known that a close relation exists between sun spots and the irregular magnetic disturbances known as magnetic storms, but no satisfactory reason for this relation has been shown.

The work of Hale and others, at Mt. Wilson, has shown that sun spots are the visible manifestation of tremendous cyclonic disturbances upon the sun. It has also been shown that powerful magnetic fields are produced over large areas in the centers of these cyclonic vortices, which fields are apparently due to convection currents set up by the rotation of negative ions around the storm centers.

It has frequently been shown that magnetic storms have the characteristics which would follow from vortex currents in the earth or in the upper atmosphere. It has been assumed that these currents are due to electrons expelled from the sun and forced into spiral paths by the earth's magnetic field.

The fact that both clockwise and counter-clockwise vortices are shown by magnetic storms in the same regions indicate that their rotational motion is not caused by the earth's magnetic field. Also, it is known that the sun has a magnetic field about 50 times as strong as the earth's field, hence no electrons can be expelled from the sun except in the direction of its magnetic axis, and would not reach the earth.

The diurnal variations in the earth's electrical potential which have been recorded at Palo Alto seem to show that the earth, as well as the sun, is highly electrified, and with negative charge. This gives plausibility to the assumption that the other planets are similarly electrified, and furnishes a theoretical basis for the conclusion, hitherto based upon empirical data, that the periodicity of sun spots depends upon the relative positions of the planets. Reference is made to the evidence furnished by La Rue, Stewart and Loewy that the sun spot area varies with the angular distance between Mercury and Venus and to the fact that the mean sun spot period of a little more than 11 years is closely related to an integral number of revolutions of each of the planets.

Thus: Mercury makes 45 revolutions in 11 years; Venus makes 18 revolutions in 11.08 years; Earth makes 11 revolutions in 11 years; Mars makes 6 revolutions in 11.25 years; Jupiter makes 1 revolution in 11.8 years.

Attention is also called to the fact that the diurnal variation of the N component of terrestrial magnetism has been shown by Chree to be about 70 per cent greater in the four-year period including sunspot maximum than in the corresponding period at sunspot minimum. This phenomenon cannot be due to the sun spots, themselves, since it is shown by the records of days of least magnetic disturbance. From the point of view of the present writer such a variation could be caused by the sun only if the total electric charge of the sun varied periodically with the sunspots. Apparently, both the disturbances in the sun's electric field which gives rise to sun spots and the increase in the diurnal variation of the earth's magnetic field must be due to electrical induction by other charges in the solar system.—Abstract from *The Physical Review*, April, 1921. Article by F. Sanford.

The Individual and the Species*

Insect Experimentation That Throws Light on the Problem of Where to Draw the Line

By Leon Bertin

WHEN we look over the numbers of the *Bulletin de la Société Entymologique de France*, or the reports of any other society engaged in the study of insects, we are struck by the great number of notes bearing such titles as "Description of New Species," "Description of a New Variety," "Classification of a New Geographical Variety of Such and Such an Insect," etc. Among the French fauna alone some thirty new species are thus *created*, so to speak, every year. . . . However, it is allowable to debate the actual value of the *sois-distant* species and varieties to which our amateur entymologists have given new names. Is it not quite possible that in many cases they have mistaken purely individual aberration of character for specific new characters? What would these naturalists think of one of their colleagues who should describe a man as the type of a separate species according to whether his complexion is dark or fair, or whether his nose is aquiline or retroussé. . . . We may remark with regard to this that insects—like most animals indeed—are essentially variable in nature. . . . Take the *Zygenæ*, for instance: moths of a blood-red color. While this is their characteristic hue it is by no means rare to find among them certain individuals with wings of a much paler shade, rather salmon-colored than bright red. Moreover, cases of albinoism, or the paling of color and of melanism, *i.e.*, the deepening of color, are extremely frequent among insects and the cause of this is usually unknown. . . .

However, when we come to the blue-winged cricket (*Oedipoda casrulescens*) which is quite common in the vicinity of Paris, and two or three specimens of which have been found with yellow wings like those of the Algerian cricket (*Oc. sulphurescens*), it is fair to suppose that this change of color is due to a perfectly natural cause, namely, the climate.

In a certain Brazilian forest a traveling naturalist discovered a definitely circumscribed area in which all of the insects, including flies, butterflies, and wood lice, were red, and another well-defined area in which they were blue. In Ceylon nearly all the native insects are green. It would seem that either the food, or the temperature, or the light, must be the factor which produces such a general uniformity of color among all the insects surrounded by the same conditions of life.

Examples of this sort might be multiplied indefinitely, but we shall confine ourselves to a single case, that of the Notonectes studied by Delcourt in 1909. These are water fleas living in ponds and in those portions of water courses where the current is retarded by water plants. After examining 30,000 of these, captured in various parts of France, he came to the conclusion that the 3 species *Notonecta glauca*, *N. marmorea* and *N. furcata* pass into each other by insensible gradations in southern regions. The spots on the wings of *N. glauca* gradually diminish until they entirely disappear in *N. furcata*. In Paris and in the north of France on the contrary *N. furcata* on the one hand and the former two species on the other hand form two groups which are distinctly different with respect both to physiology and to morphology. It is evident from this example that environment is a powerful factor in the variation of animals, since the relations of these 3 species have been so greatly altered by a difference of merely a few degrees of latitude.

Thus mere observation leads us to conclude that living organisms are variable under the influence of the different factors which condition their existence (temperature, humidity, light, food, etc.).

While the first method of study in every natural science consists of observation, the second method is that of experiment. Observation suggests the hypotheses which it is the object of experiment to verify. . . . In this article we shall attempt to find out whether the hypothesis that the medium exerts an effect upon all living creatures is true or false . . . by a study of various classes of experiments.

I. TEMPERATURE EXPERIMENTS

The more humid portions of our woods are frequented in the summer by a butterfly having wings of a black or dark brown color marked by a standing row of white spots. This is known to entomologists as the *Vanessa prorsa*. It lays its eggs at the end of the summer and its caterpillars appear and form chrysalids, from which then issue, after they have survived the rigors of the winter, not the *Vanessa prorsa*, as one might have expected, but a butterfly long known as the *Vanessa levana*, having light-colored wings marked by black spots. The eggs of these develop very rapidly and produce once more the *Vanessa prorsa* having dark wings with light spots, and there is a regular alternation between these generations of spring and of summer. . . . Professor Weissmann, of the University of Fribourg, undertook an experimental study of these alternating generations. He found that the *levana* chrysalids are normally transformed into *V. prorsa*, but that when subjected to cold in an icebox they produce *V. levana*—in other words there ceases to be an alternation of generations. Inversely, the chrysalids produced by the *prorsa* generation, when kept at a high temperature (15 to 40 deg. Cent.) produce finally, instead of the *levana* generation, butterflies of a new sort, *V. porima*, which have large black spots upon their wings and form an intermediate variety between the other two. It is a remarkable fact that this *V. porima* is sometimes found in nature, in the fall of the year when specially favorable conditions of the atmosphere have caused the *prorsa* larvæ to develop very rapidly.

Without dropping the subject of the *Vanessa* butterflies, which have always been popular with the public because of the graceful contours and brilliant colors of their wings, we may cite some temperature experiments made by Standfuss from 1886 to 1900:

Chrysalids of the small tortoise-shell butterfly, *V. urticae* were reared for a greater or lesser length of time either in an oven kept at a temperature of 40 deg. Cent. or else in an icebox. Under the influence of the heat there were produced butterflies having darker colors than usual and resembling the *ichnusa* variety of Corsica and Sardinia, where the climate is a warm one. Cold, on the contrary, produced the light-colored variety *polaris* found in Scandinavia.

Standfuss also subjected chrysalids of *V. urticae* to "shocks" of cold or heat, *i.e.*, to very low temperatures —8 deg. Cent.) or very high ones (45 deg. Cent.) for a few hours each day. Very pronounced changes in color were thus produced . . . these were very irregular . . . and too complex to be fully explained in the present state of our knowledge.

The special interest taken by Standfuss in these variations among the *Vanessa* which haunt nettles was related to his studies of the inheritance of acquired characteristics. . . . He selected males and females which had been rendered abnormal by the effect of cold. 2000 caterpillars were obtained from the pairing of 8 females and 30 males. But various maladies, such as are almost inevitable in the rearing of a large number of lepidoptera, decimated the group. Only 500 caterpillars succeeded in becoming successfully transformed into chrysalids and from these 200 butterflies were obtained. But among these 196 were normal while 4 (all males) were ab-

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), for March 19 and 26, and April 2, 1921.

normal in the direction of the parent type. This experiment therefore is very far from being favorable to the hypothesis that acquired characters may be transmitted by heredity.

Another entymologist of Zurich, Fischer, made use for his experiments, in place of *Vanessa*, of a night moth having a very brilliant sheen; this butterfly which is red marked with large, black spots is known to collectors under the name of *Arctia caja*. His experiments made in 1899 gave the following results: 135 caterpillars were raised in a state of captivity, 102 entered the state of chrysalids and were divided into two lots, 54 in one and 48 in the other. The first lot were kept at the ordinary temperature and the second lot was subjected to an intermittent temperature of 8 deg. Cent. below zero. While all the butterflies issuing from the first lot of chrysalids were normal in color, 41 out of the second lot exhibited a considerable increase of size in the black spots upon their wings.

In a complementary experiment with respect to heredity, males and females of the *Arctia caja* chosen among those which were most melanic in character were paired and the resulting eggs were developed in cages of the ordinary temperature. All the butterflies obtained except a very few were normal, thus furnishing a new proof of the non-heredity of the acquired characteristics—*at any rate under the conditions of the experiment.*

Following the experiments of Fischer in point of time, are those of the Geneva scientist, Pictet (A. Pictet *Mém. Soc. Phys. et Hist. Nat.*, Geneva, 1912, Vol. 37). These constitute an investigation of enormous extent, relating to various species of butterflies which were submitted to an elevation or a lowering of the temperature. These experiments, together with those of Pictet's predecessors enable us to formulate certain general laws with respect to the variation of insects.

From 1904 to 1911 several thousand chrysalids of the *V. urticae*, caught in the vicinity of Geneva, were subjected to high temperatures. Each lot was kept for a definite number of hours at a temperature of 40 to 45 deg. Cent. The phenomena first observed consisted in the liberal appearance of albino and melanic forms. The varieties *V. ichnusa* and *V. polaris* obtained by Standfuss through the contrary effects of heat and of cold were in this case both obtained by the action of heat. Furthermore, the changes of color were produced in only a small number of the butterflies. About half of the chrysalids were in no way influenced by the action of the heat. We may add that a microscopic examination revealed that the super-coloration and the decoloration of the wings were due to a greater or less abundance of the *ordinary* pigment. As a matter of fact the melanism is due to the circumstance that the normal coloring mater is produced in greater quantities. The diminished size of the scales charged with pigment is an added cause of the albinoism.

1. By subjecting Vanessa chrysalis to variations of temperature Weissmann, Standfuss and Pictet have succeeded in obtaining artificially, both geographical races (the *ichnusa* and the *polaris varieties of V. urticæ* and seasonal forms (*V. prorse, levana, porima*). It is therefore, highly probable that the same factors, which are climatic in character, act in the same way in a state of nature.

2. *Not all chrysalids are equally sensitive to variations in the external medium.* There may be a *critical point, i.e.*, a precise moment in the evolution of the nymph at which the temperature is effective in producing variations in morphology.

3. All the changes of color obtained by experimental variations of temperature may be reduced to the intensification or the attenuation of the color—in other words to *melanism* and to *albinoism.* There is merely an increase in size or a contraction of certain spots upon the wings—no new color ever makes its appearance.

This *law of variations by means of the melanism or the albinoism of certain portions* was first formulated by Overthur in 1893. It tends to diminish the importance previously ascribed to variations of color in insects.

4. *The same variations can be produced either by a rise or by a fall of temperature. Reciprocally two opposite variations—a supercoloration and a decoloration—may be due to the same cause.*

Professor Tower's Experiments.—Apropos of this we may cite the extensive experiments covering some ten years made by Professor Tower of the University of Chicago, upon the American potato bug (*Leptinotarsa decemlinetta*). The color and the marking of the different parts of the body are here very variable among individuals of the same collection. . . . Those species which are most widely distributed geographically were found to be most variable, since the differences of the environment with respect to temperature, light, humidity, and food varied more widely than in more restricted areas. . . . Thousands of larvæ reared in cages at a temperature several degrees higher or lower than that of the surrounding air, produced more or less modified adult insects. . . . Whenever the change in the degree of heat was slight, whether higher or lower, melanism occurred, while albinoism was produced when this difference was of considerable amount. Professor Tower says: "Among the thousands of variations of color which I have produced none displayed the slightest sign of being permanent in successive generations or in hybrids and they ceased to be capable of selection *as soon as the cause which had produced them disappeared.*" . . .

II. EXPERIMENTS IN HUMIDITY

The English colonial naturalist, Marshall, describes the existence in the Transvaal of the two forms *octavia* and *sesamus* of the same butterfly of the genus *Precis*, the former having salmon-covered wings adorned with black spots and frequenting, during the *humid season* (corresponding to our winter), high and treeless localities. The *sesamus* form, on the contrary, has red wings marked with blue spots and appears in great abundance during the *dry season* in woods and forests or near human dwellings. The eggs of one of these forms produce adults of the other and vice versa. Other investigators working with a different subject (*Melanitis leda*, etc.) have succeeded in producing at will the dry season forms and the humid season forms by rearing the chrysalid in a dry or humid atmosphere. . . .

Apropos of this Tower found in his potato bug experiments that an increase or decrease of the amount of moisture in the atmosphere produced precisely the same variation as the changes of temperature—namely, first melanism and next albinoism. . . .

5. To these four laws we must now add a fifth which is of the greatest possible importance, namely; the same change of color is capable of being produced in one direction or in the other by a variation in the degree of humidity as well as by a variation in the degree of temperature. *In other words, the different factors of the environment do not exhibit any specificity of action.*

III. EXPERIMENTS WITH LIGHT

Adult insects rarely exhibit as great a response to light as do their caterpillars or chrysalids. Maria von Linden found only a slight variation in size in certain butterflies whose larvæ had been reared in boxes made of glass of different colors. Such experiments are of interest merely as confirming the second law formulated by Pictet, namely, that there is a *given moment*, in other words there is a *definite critical point* in the life of an insect when it is necessary for the external factor to operate in order that a variation in form may be produced.

As a matter of fact it is probable that the reason why most of the experiments with light undertaken by Weissmann, Standfuss, Fischer, Blanchard, Cholodkovsky, etc., have not given satisfactory results is because these authors exposed to the colors of the solar light any sort of caterpillars without regard to the critical point referred to above.

When a caterpillar of the *Vanessa urticæ* is about to become

a chrysalid it descends from the nettle upon which it has been feeding, finds a suitable location and then hangs head downward until the skin splits and falls off, leaving behind the grotesque chrysalid; the immobile period just preceding the dropping of the skin is called by Poulton Stage II.

If caterpiliars are placed, in this stage—*and in no other*—in a glass tube covered with white paper, or better still gilt paper, the chrysalids which shortly appear are unusually beautiful, looking as if they had been covered with gold leaf instead of being black, as they are in nature. When gilt paper is employed more than 85 per cent of the chrysalids are golden in hue. Moreover, the 15 per cent which remained dark must have been in the shadow of the others in the same tube.

Was this result due to an actual color photography? Poulton has proved that the nervous system of the caterpillar is at least partly responsible for the effect. He suspended a caterpillar in this stage in a glass box covered with black paper at the top and gilt paper at the bottom, or vice versa. The chrysalid which appeared was not parti-colored in black and gold, as might have been expected, but all one color, that of the light to which the greater part of its body had been exposed. Evidently the nervous system had operated to render the color uniform. . . . The experiment resulted in the same manner when the eyes of the caterpillar were covered with an opaque varnish, hence vision played no part.

IV. EXPERIMENTS IN FEEDING

Since development is the immediate effect of feeding living creatures, it is *a priori* evident that any modification in the amount or quality of the food must be an important source of variations in form. . . .

In defining any given species of animal we take into account, *inter alia*, the dimensions, since the size varies within but narrow limits among either individuals or generations. Size may be regarded as typical of the characteristics termed *fluctuating*. . . . While both giants and dwarfs are produced at times, they leave no descendants. . . .

This would cause us to expect that efforts to alter the size would be futile. But in 1903 Kellogg and Bell succeeded in producing dwarf races of silk-worms by feeding them upon lettuce instead of the more nourishing mulberry leaves generally fed to them. They remained dwarfs for successive generations even when restored finally to the mulberry leaf diet.

CHANGES OF COLOR PRODUCED BY FEEDING

Color changes due to food are much more marked than change of size. . . . In 1896 Standfuss obtained butterflies of the *Callimorpha dominula* with yellow wings instead of the normal red by giving the caterpillars a diet of leaves which had been soaked in a solution of ordinary salt. This result accords with the observation that specimens of this species reared upon the seacoast often have posterior wings of a yellowish hue.

Poulton divided a single deposit of *Tryphaena pronuba* eggs into two lots, feeding the first lot with complete cabbage leaves and the second lot with those parts of the leaf which entirely lack chlorophyll. The first soon became green or brown as in nature, while the second remained colorless. While this suggests that the color of the caterpillars is due to the green coloring matter of the cabbage, it remains to prove this by chemistry and the microscope.

Most remarkable of all in this line are the experiments made by Pictet. . . . *Ocnerià dispar* or *Lymantria d.*, or *Liparis d.*—the names are synonymous—is an ugly dark brown night moth often called Zig-Zag by farmers because of the broken black lines which adorn its upper wings. The females bear the same marks on a white ground, and are also larger than the males. Normally they live on the oak and the birch. . . . Pictet obtained the following results on changing the food: When fed on the leaves of the walnut the males were altered as follows: 1. The size was reduced. 2. The color was pale, ranging from brown to yellow and even to white. 3. There was an attenuation, or even an entire disappearance, of the zig-zag marks. All of these acquired characters probably indicate a degeneration of the race. If the same diet is continued they are accentuated in later generations, but attenuated when the normal diet is returned to. We shall see later what this suggests with respect to the heredity of acquired characteristics.

When fed on sainfoin or "French grass" the caterpillars of this species produce butterflies with still different acquired characters. . . . If we give oak leaves to the first generation, walnut leaves to the second, and sainfoin to the third we obtain "harlequin" butterflies, of the three colors superposed. . . .

In this species, and in general in all the Bombzeides the caterpillars from which males are produced differ in aspect from the other sex. In other words sexual dimorphism exists even in the larval state. But when they are fed upon walnut leaves and are therefore ill-nourished all of the caterpillars look like males, although they produce both sexes in the usual proportions. But when fed with the much richer nutriment of the sainfoin, all of the caterpillars exhibited the secondary characters of females, although they produced a constant proportion of the two sexes as in the preceding case and as in nature. These facts tend to establish the independence of sex and secondary sexual characters. . . .

Pursuing the same idea Pictet came very near accomplishing a transformation of the *Vanessa polychloros* into the *V. urticæ* by feeding the caterpillars of the first species upon nettle leaves.

In 1907 Marchal made analogous experiments with the cochineal insect of the acacia. This plant was introduced from America into Europe in the 17th century. . . . Until 1881 it did not suffer from attacks by cochineal insects either in its native or acquired home, but in that year the European trees were attacked by a species of cochineal insects which was termed a new species by a specialist of the period and called the *Lecanium robiniarum*. Where did this come from?

Marchal answers this question by declaring that this new species is due to the transformation of the peach tree cochineal (*Lecanium corni*). The newly hatched larvæ of *L. corni* were placed upon the limb of a young acacia. They suspended themselves to the leaves and in the fall a number of them attached themselves to the bark in order to pass the winter. The others died in large numbers. Those which were attached to the wood appeared the next spring in the form of *L. robiniarum*, recognizable by their larger size and their darker color. Thus the passage from one species to another was accomplished in a single generation. Intermediates in nature between *L. corni* and *L. robiniarum* are the *L. vini* and *L. wistariæ*. Thus there is a different sort of cochineal insect for each sort of nutritious sap. This suggests states of equilibrium in chemical compounds governed by temperature and pressure.

V. VARIOUS EXPERIMENTS

The electric state of the atmosphere forms part of the conditions of life which control terrestrial organisms. It is not surprising that it should modify butterflies at certain periods of their existence. It has been noted, for example, that those specimens of *Arctia caja* which issue from the chrysalid in stormy weather often exhibit anomalies of color. Other chrysalids, upon being submitted to discharges from an induction coil are transformed into melanic butterflies. . . . Professor Mercier of Caen has reported a curious example of the effects of the ordinary agents of modification, pressure, contact, shock. The pupæ of a small fly (*Fucellia mantima*) were placed in narrow glass tubes closed with stoppers of cotton-wool. The flies which were born could not turn around and sought to escape by thrusting the head against the stopper or the walls of the tube. The frontal vesicle thus alternately swells and contracts while still soft. But suddenly the chitin becomes rigid so that the flies retain thereafter a horn between the eyes. . . . These are experimental but similarly

horned flies have been found in nature. This experiment has extensive implications:

1. It shows that young insects have malleable figments which can be affected by external mechanical factors. 2. If we suppose several successive generations to be born within similar narrow glass tubes, all of them evidently would exhibit the frontal horn. This horn would be, in fact, acquired anew in each generation. Here we would have then a simulation of heredity, but not true heredity. . . .

Let us now consider the Phasmas, those large orthopterous insects which so closely resemble the twigs of trees, *e.g.*, the *Bacillus gallicus* of the south of France. Their strange aspect is due to the fact that the femurs are so curved as to exactly fit the head, thus forming a straight line with the body. These peculiar curves of the legs are considered specific characters by entomologists, so that one would naturally believe that they are hereditary. This is not the case, however. The curve is imparted at the moment when the insect issues from the egg. At that time the femurs are still soft and are pressed tightly against the head, so that they adapt themselves mechanically to the contour of the latter. For this reason all of the phasmas exhibit the same curves of the femur, merely because they experience the same difficulties in escaping from the egg. Here we see that *the exact repetition of identical conditions of development may take the place of heredity in the determination of the fixed characteristic of a species.*

Let us now consider such questions as the following: What is the cause of the lack of wings, *i.e.*, apterism in certain insects? Why do certain others bear their young alive? etc.

1. *Lack of Wings*—We may recall that Darwin, Wallace, and others have sought to explain the lack of wings by the famous law of natural selection.

In certain cases this lack has been ascribed to a parasitic or sedentary habit (fleas, bed bugs and lice; the Melophages of the fleece of sheep, etc.).

The only experimental work of value along this line has been done by Dewitz and certain American scientists.

Dewitz procured insects with wings reduced to nil by putting the nests of wasps (*Polistes gallicus*) in an icebox; he also made similar experiments with the very young larvæ of the common blue fly (*Calliphora vomitoria*). This experiment agrees with the curious discovery of a wingless fly (*Belgica antarctica*) in the polar region by the Belgian Antarctic expedition. The pupa of this fly possesses wings which are atrophied in the adult, apparently because of the severe cold.

The American savants referred to above sought to discover why winged generations of plant lice, which are ordinarily apterous, appear in the autumn. They planted a rose stalk covered with the young lice in sand watered with various solutions containing minerals or sugar which the lice imbibed along with the sap. Some solutions were found to prevent the forming of wings while others favored this (the sugar solutions). This is particularly instructive when we recall that at the approach of winter plants transform their reserves of starch into sugar. In this case the cold acts upon the lice indirectly through the production of sugar in the sap instead of directly as we must assume it to have done in the Dewitz experiment.

2. *Viviparous Insects.*—Some insects produce their young in a more or less advanced stage of development. It used to be thought that this was due to simple factors such as a high temperature or very rich food (especially in the case of blood-sucking insects. It was thought that the cattle fly (*Musca corvina*) was oviparous in northern Russia and viviparous in the south. But the Russian entomologist Portchinsky, who had stated this to be the fact, later found it to be an error. There are really two distinct species, and in Central Russia both are found feeding upon the same food.

In 1840 von Siebold noted certain facts about the blue meat fly which were confirmed by Guyénot in his experiments with the vinegar fly (*Drosophila ampelophila*) in 1908-1914. . . . He found that if the *life* conditions (food, temperature) of a female vinegar fly be changed in *any manner whatever* when the insect is about to deposit its eggs the function will be retarded for a longer or shorter time. If a female which has been reared upon beer yeast is moved suddenly when about to lay its eggs into a fresh tube containing potato or carrot it becomes viviparous instead of oviparous. The retention of the eggs is so accentuated that they hatch within the mother's uterus. In this case the viviparity is due to insufficient food—or perhaps merely to the change of tube. It is impossible not to conclude that viviparity in insects is an extremely complicated phenomenon.

VI. CONCLUSIONS

The problem of the influence of environment upon living creatures is one of the most hotly debated questions in modern biology. During the last 50 years a good many experiments have been made upon different animals to see whether changes in food, temperature, humidity, etc., can produce hereditary or temporary alterations. Insects of different kinds have formed the subject of many of these experiments.

Some experimental variations are in accord with those observed in nature. This renders them important since they enable us to explain: 1. Geographic races. 2. Seasonal forms. 3. Certain forms very closely adapted to given conditions of existence.

However most of the changes in form due to changes in food, temperature and humidity appear to be of minor importance, as for example: 1. Changes of color producing melanism or albinoism. The same pigment is increased or diminished without undergoing a chemical change. The gamut of variation is limited to the following colors: white, yellow, red, brown, black.

2. The same variation may be produced by any factor whatever, rise or fall in humidity, etc. Thus the disappearance of the blue "half-moons" of the nettle butterfly through an extension of the black border of the wings may be due to an excitation which may be produced by heat, humidity, light, electricity, or by rotation for 5 minutes a day during the nymphal period. Weissmann carried upon a railroad journey some caterpillars of the summer generation of the *Pieris napi* and obtained from them the winter generation just as if he had put them in an icebox.

3. Insects subjected to experiment have a high rate of mortality—many of the animals exhibiting pathological changes.

This last observation emphasizes the great interest attached to the experiments of Guyénot with respect to aseptic life and the development of the organism (*Drosophila melophila*) in function of the environment.

A number of scientists, especially in America, studied these same vinegar flies before Guyénot. The eyes became white, pink, red, or orange with astounding facility. The wings were rudimentary, truncated, beaded, etc. The innervation of the wings underwent unexpected changes. But while the effect of environment upon vinegar flies has never been denied it remained for Guyénot to devise an experimental method strictly enough controlled to demonstrate it. . . . No experimental study of variation can carry scientific conviction unless there is an absolutely accurate knowledge of the milieu in which the insects live. . . .

Guyénot's method consists of *aseptic rearing.* The flies are kept entirely free throughout their lives from microbes and other parasites which might interfere with the accuracy of the experiments. The ordinary unsanitary cages are replaced by sterilized vials and tubes. The food (yeast, potato, carrot) is sterilized by heat, or better, consists of artificial substitutes whose chemical composition is exactly known. The atmospheric conditions are rendered absolutely stable. . . . This principle of aseptic rearing in animals which are subjected to experiment ought to have a universal application, since it is the *sine qua non* in the experimental study of variations.

The Infancy of Illuminating Gas

How the Original Discovery Was Made by Murdock and How He Brought It Into Use

By Ralph Howard

PART I.

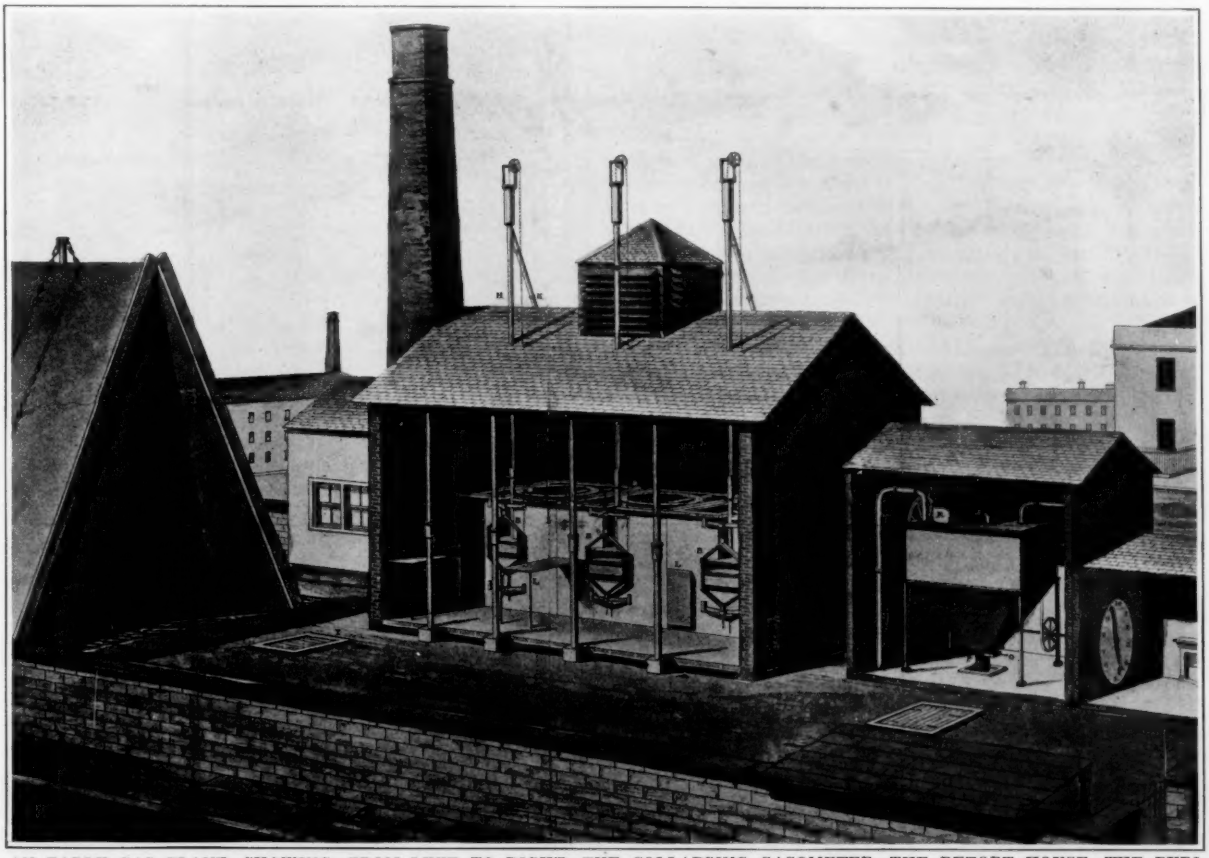
MR. MURDOCH'S PAPER

AN English firm of scientific booksellers recently catalogued two very important items relative to the early history of gas manufacture, including Murdoch's original paper, read before the Royal Society February 25th, 1808. This is the earliest practical essay on the subject and was awarded the Rumford gold medal. The other item is a technical treatise on coal gas, dated 1819, written by Frederick Accum, "operative chemist." We were fortunate enough to secure both of these items, and we can now give our readers one of the most interesting insights in the early history of a great industry which has done so much for the human race. We can begin this résumé most appropriately by quoting William Murdoch's paper referred to. The title was "An Account of the Application of the Gas from Coal to Economical Purpose. By Mr. William Murdoch. Communicated by the Right Hon. Sir Joseph Banks, Bart. K.B.P.R.S."; and Mr. Murdoch's text follows:

"The facts and results intended to be communicated in this paper are founded upon observations made during the present winter, at the cotton manufactory of Messrs. Philips and Lee at Manchester, where the light obtained by the combustion of the gas from coal is used upon a very large scale; the apparatus for its production and application having been prepared by me at the works of Messrs. Boulton, Watt, and Co., at Soho.

"It is not my intention, in the present paper, to enter into a particular description of the apparatus employed for producing the gas; but I may observe generally, that the coal is distilled in large iron retorts, which during the winter season are kept constantly at work, except during the intervals of charging; and that the gas, as it rises from them, is conveyed by iron pipes into large reservoirs, or gasometers, where it is washed and purified, previous to its being conveyed through other pipes, ralled mains, to the mill. [The ultimate consumer in this instance.] These mains branch off into a variety of ramifications (forming a total length of several miles), and diminish in size, as the quantity of gas required to be passed through them becomes less. The burners, where the gas is consumed, are connected with the above mains, by short tubes, each of which is furnished with a cock to regulate the admission of the gas to each burner, and to shut it totally off when requisite. This latter operation may likewise be instantaneously performed, throughout the whole of the burners in each room, by turning a cock, with which each main is provided, near its entrance into the room.

"The burners are of two kinds: the one is upon the principle of the Argand lamp, and resembles it in appearance; the other is a small curved tube with a conical end, having three circular apertures or perforations, of about a thirtieth of an inch in diameter, one at the point of the cone, and two lateral ones, through which the gas issues, forming three divergent jets of



AN EARLY GAS PLANT, SHOWING, FROM LEFT TO RIGHT, THE COLLAPSING GASOMETER, THE RETORT HOUSE, THE PURIFYING HOUSE, AND THE OFFICE AND METER ROOM

flame, somewhat like a fleur-de-lis. The shape and general appearance of this tube has procured it among the workmen, the name of the cockspur burner.

"The number of burners employed in all the buildings [of the Manchester mill] amounts to 271 Argands, and 633 cockspurs; each of the former giving a light equal to that of four candles of the description above mentioned; and each of the latter, a light equal to two and a quarter of the same candles; making therefore the total of the gas light a little more than equal to that of 2500 candles. When thus regulated, the whole of the above burners require an hourly supply of 1250 cubic feet of the gas produced from cannel coal; the superior quality and quantity of the gas produced from that material having given it a decided preference in this situation, over every other coal, notwithstanding its higher price."

Condensing Mr. Murdoch's text here, it appears that the consumption of gas at the Philips' and Lee's mill was 2500 cubic feet of gas a day. In 313 working days 110 tons of cannel coal were used, costing £125. The by-product was reckoned with even in those days, for we find 70 tons of "good coak" remaining which was sold for £93, therefore the total expense for coal was only £32. Mr. Murdoch says:

"The quantity of aqueous fluid which came over in the course of the observations which I am now giving an account of was not exactly ascertained, from some springs having got into the reservoir; and as it has not been yet applied to any useful purpose I may omit further notice of it in this statement."

If he had only known the value of the by-products, he would not have referred so lightly to this. He estimated that the total cost of lighting by gas of this factory was £650, while for tallow candles the expense would have been £3000. Here the first great victory for gas was scored. Mr. Lee's house nearby was also "brilliantly illuminated." So we have the first case of domestic lighting. Our authority then goes on to describe his discovery of illuminating gas.

"It is now nearly sixteen years, since, in a course of experiments I was making at Redruth in Cornwall, upon the quantities and qualities of the gases produced by distillation from different mineral and vegetable substances, I was induced by some observations I had previously made upon the burning of coal, to try the combustible property of the gases produced from it, as well as from peat, wood and other inflammable substances. And being struck with the great quantities of gas which they afforded, as well as with the brilliancy of the light, and the facility of its production, I instituted several experiments with a view of ascertaining the cost at which it might be obtained, compared with that of equal quantities of light yielded by oils and tallow.

"My apparatus consisted of an iron retort, with tinned copper and iron tubes through which the gas was conducted to a considerable distance; and there, as well as at intermediate points, was burned through apertures of varied forms and dimensions. The experiments were made upon coal of different qualities, which I procured from distant parts of the kingdom, for the purpose of ascertaining which would give the most economical results. The gas was also washed with water and other means were employed to purify it.

"In the year 1798 I removed from Cornwall to Messrs. Boulton, Watt and Co.'s works for the manufactory of steam engines at the Soho Foundry, and there I constructed an apparatus upon a larger scale, which during many successive nights was applied to the lighting of their principal building, and various new methods were practised, of washing and purifying the gas.

"These experiments were continued with some interruptions until the peace of 1802, when a public display of this light was made by me in the illumination of Mr. Boulton's manufactory at Soho, upon that occasion.

"Since that period, I have, under the sanction of Messrs. Boulton, Watt and Co., extended the apparatus at Soho Foundry, so as to give light to all the principal shops, where it is in regular use, to the exclusion of other artificial light; but I have preferred giving the results from Messrs. Philips' and Lee's apparatus, both on account of its greater extent, and the greater uniformity of the lights, which rendered the comparison with candles less difficult.

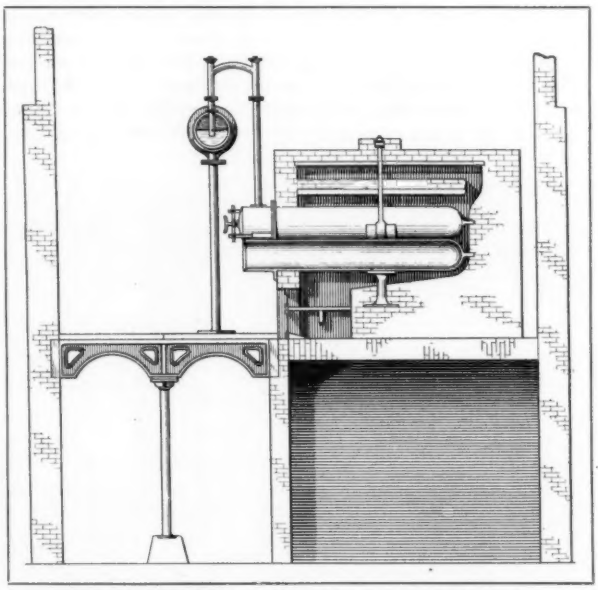
"At the time I commenced my experiments, I was certainly unacquainted with the circumstance of the gas from coal having been observed by others to be capable of combustion; but I am since informed, that the current of gas escaping from Lord Dundonald's tar ovens had been frequently fired; and I find that Dr. Clayton, in a Paper in Volume XLI. of the Transactions of the Royal Society, so long ago as the year 1739, gave an account of some observations and experiments made by him, which clearly manifest his knowledge of the inflammable property of the gas, which he denominates "the spirit of coals;" but the idea of applying it as an economical substitute for oils and tallow does not appear to have occurred to this gentleman, and I believe I may, without presuming too much, claim both the first idea of applying, and the first actual application of this gas to economical purposes."

PART II.

FURTHER HISTORY OF GAS LIGHTING

Frederick Accum, the author of the very excellent treatise on gas manufacture (for the time) appears to have been identified with the industry almost from its inception. He says:

"Capital, often wanting even in this opulent country for



AN EARLY FORM OF RETORT FOR GAS-MAKING

undertakings of magnitude, came to the promotion of the new art of procuring and distributing light in overflowing abundance; and already ere many years are elapsed, such has been the rapidity with which the gas light illumination has advanced that there is not a city and scarcely a town of any note in Great Britain, in which the art of lighting by means of gas has not been carried into effect, or in which active measures are not in progress, to participate in the benefit of this important discovery."

He was also familiar with other sources of gas than coal, for we find a little farther on the following:

"I have added an account of the manufacture of carburetted hydrogen gas, from coal tar, vegetable tar, and oil, with such other observations as may enable the reader to form a proper estimate of the comparative advantage of manufacturing gas from oil, or tar, under certain circumstances. I have here also given an account of the manufacture of carbonate of ammonia, as now practiced, from the ammoniacal liquor obtained in the gas light process, and of the manufacture of other saleable

products obtainable from coal, namely, pitch, coal tar, and oil."

At the time he wrote there were 51,000 gas lights in London alone, so we may consider that the industry was firmly intrenched in 1919. His description of the value of gas is naïve. He says:

"It must be difficult for a person wholly unacquainted with this art, to imagine with what facility and neatness gas lights are managed. The gas being collected in a reservoir, is conveyed by means of tubes, which branch out into smaller ramifications, until they terminate at the places where the lights are wanted. The extremities of the branching tubes are furnished with burners, having small apertures out of which the gas issues with a certain velocity corresponding to its degree of pressure. Near the termination of each tube there is a stopcock, or valve, upon turning which when light is required, the gas instantly flows out in an equable stream. *There is no noise at the opening of the valve, no disturbance in the transparency of the atmosphere;* the gas instantly bursts on the approach of a lighted taper into a peculiarly brilliant, soft and beautiful flame; it requires no trimming or snuffing to keep the flame of an equal brightness. Like the light of the sun itself, it only makes itself known by the benefit and pleasure it affords.

"The gas flame is entirely free from smell. The gas itself has a disagreeable odor before it is burnt, and so has the vapor of wax, tallow and oil as it comes from a candle or lamp newly blown out. This concession proves nothing against the flame of gas, which is perfectly inodorous.

"The gas-light flame is perfectly steady; a benefit which persons accustomed to read or write by candle-light are particularly capable of appreciating. With the other modes of illumination we have never the light of the same intensity for two minutes together, independent of that unpleasant dancing, unsteady flame which is so harassing to the sight.

"The saving of labor connected with the employment of gas-light may seem on a small scale to be trifling; but when it is considered that in large manufactories it is not unusual to find several persons employed for no other purpose than trimming the lamps or setting and snuffing the candles of the establishment, the advantage gained on this head by the use of a species of light which require no sort of attention whatever, cannot but appear very considerable."

The use of gas for purposes other than illumination were evidently well known, for he says:

"Numerous applications of gas, as a source of heat for airing rooms, and other purposes, have already been adopted. It is used in kitchens for keeping meat warm, and for boiling water, in store rooms, in picture galleries, in libraries, for maintaining them at an equal temperature. By copper-plate printers, it is used for warming their plates, and by jewelers and other artists, for soldering."

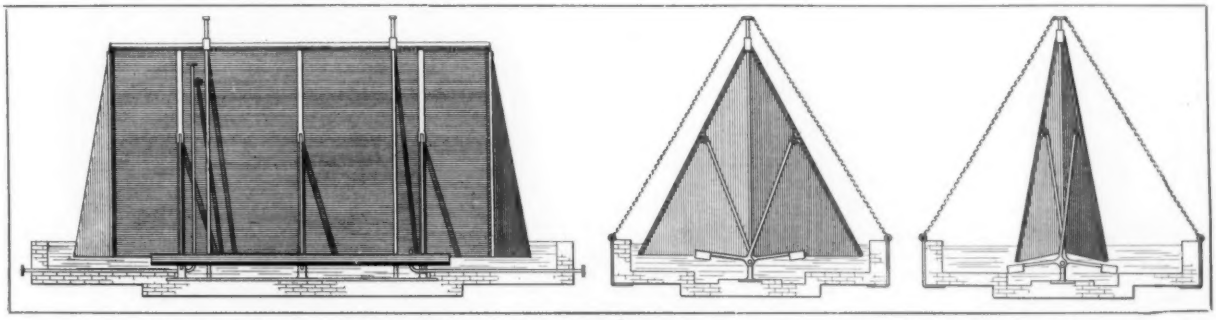
He then goes on to describe the by-products, the coke (which has by this time been spelled in the modern style), tar and ammonia, for of course anilines were not thought of in those days. He cautions all persons not to erect their own plants unless the expense for lighting exceeds 40 pounds sterling. He also suggests that the residents of a street or district club together and build a plant.

The technical descriptions of the gas generating plants are interesting, and the beautiful colored plates rank high in the early history of technical literature. We illustrate two of the plates which give an idea of the processes required. Retorts of all sizes and shapes were adopted, including semi-cylindrical retorts somewhat of the shape we now use, with covers rendered air and gas-tight by a lute, and horizontal rotary retorts, which appeared about 1816, having been invented or at least endorsed by a man named Clegg. One of our engravings show the installation at the Royal Mint of this rotary retort.

RETORTS

The horizontal rotary retorts at the Royal Mint are hollow cylinders, eight feet six inches in diameter and 15 inches high arched a little at the top. They are made of wrought-iron plates, half an inch thick, riveted together in the manner of a steam-engine boiler.

Through the center of the retort passes perpendicularly an iron shaft as shown in the section of the retort. The lower extremity of the shaft revolves upon the bottom of the retort, in a cup-shaped cavity, while its upper extremity passes through the roof of the retort, where the latter is made air-tight by means of a pipe, closed at the top and surrounding the shaft, and hence the shaft must always preserve its center.



EARLY COLLAPSING GASOMETER, IN SIDE VIEW, AND IN END VIEW BOTH INFLATED AND EMPTY

To the lower extremity of the shaft is keyed a box or center piece (technically called a rose center). From this shaft radiate twelve wrought-iron arms, fixed in sockets made in the box. These arms are elevated three inches above the bottom of the retort, and extend to nearly within its whole inner circumference. They are wedge-shaped, and their greatest diameter is at right angles to the base of the retort, so that the weight of the arms rests on the axis. They are intersected by two concentric rings. Between the arms are placed twelve shallow iron trays or boxes, destined to contain the coal from which the gas is to be obtained. They are formed to the segment of a circle, hence the whole series of them when arranged in the retort, exhibits a shallow circular tray, which, when motion is given to the shaft, may be made to revolve within the retort. It will be obvious, that by motion of the shaft, any number of trays or coal-boxes can readily be brought from the coldest, into the hottest, and from the hottest into the coldest part of the retort.

It would be interesting to know why these retorts were never used in later times. The gas was purified by what is known as the "lime machine."

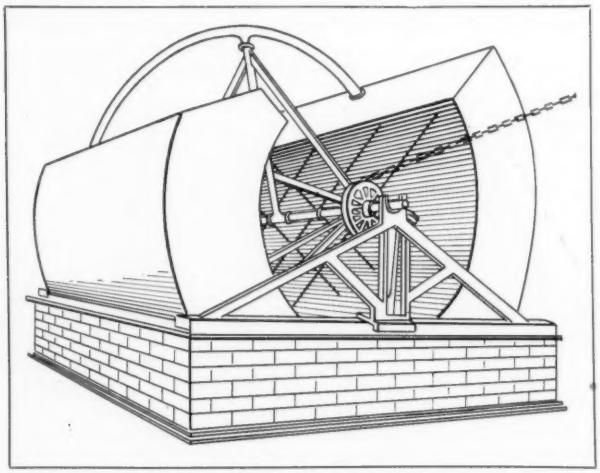
PURIFICATION

"In the lime-machine the gas was made to pass in the apparatus, through passages which could not be guarded from being stopped up in the course of time by the concretion of a quantity of carbonate and hydro-sulphuret of lime, formed during the purification of the gas, so that when the stoppage occurred,

a prodigious pressure was produced in the machine, in consequence of which it was either found impossible to keep the distillatory apparatus air-tight, or if this was accomplished, a great part of the gas was forced through the purifying apparatus without coming in contact with the lime, by driving the column of mixture of lime and water before it, and of course without being rendered fit for use, previous to its passing into the gas reservoir. This effect was unavoidable without the precaution of employing a very dilute mixture of quick-lime and water. Numerous instances have also occurred where from the increased pressure which the gas exerted in the lime apparatus the tar from the hydraulic main was driven up with a prodigious force through the dip pipe, into the retort when the retort was opened, where it took fire to the imminent danger of the whole establishment."

THE GAS HOLDER

"The name of gas holder, or, as it is improperly called, 'gasometer,' is given to the vessel employed for collecting the gas and storing it up for use. In the principle and construction of this part of the gas light machinery, peculiarly valuable improvements have of late been made. They have contributed to lessen the expense of the apparatus so much that a reservoir for storing up any quantity of gas may now be furnished for



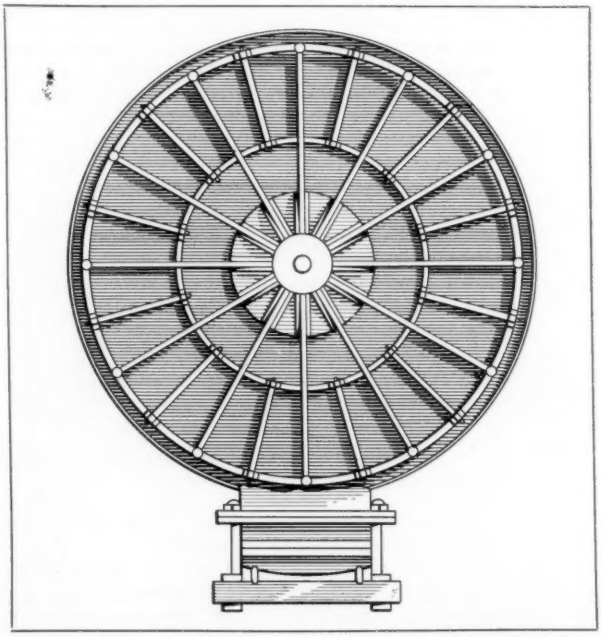
A BALANCED GASOMETER OF UNUSUAL TYPE

nearly one-half the sum which such a vessel cost as originally constructed. In the infancy of the art of lighting with coal gas, the reservoir was encumbered with a heavy appendage of chains, wheel-work and balance weights, and from the construction of the machine it was necessary to guard it from the impulse of the wind, the action of which on the gas holder would have rendered the lights which the machine supplied with gas, unsteady. Hence it was necessary to inclose the gas holder in a building, called the gasometer house, which formed one of the largest items of expenditure which the proprietor of a gas light establishment was called upon to defray. Now, however, [it is Accum speaking], the whole of these expensive appendages is dispensed with, nor is the gasometer house to contain the gas holder any longer necessary, and the machine as now constructed may be fixed in the open air.

"The gas holder, of the original construction, consists of two principal parts: first, of a cistern or reservoir of water, usually constructed of masonry, or of cast-iron plates, bolted and screwed together; and secondly, of an air-tight vessel which is closed at top and open at bottom, inverted with its open end downwards into the cistern of water. This vessel is always made of sheet-iron plates riveted together air-tight, and was suspended by a chain or chains, passing over wheels, supported by a frame work.

"If the common air be allowed to escape from the inner vessel, when its open end is under the edge of the water, in the outer cistern, it will freely descend, and water will occupy the place of the air; but if the avenue of the escape be stopped, and air be made to pass through the water, the suspended inverted vessel will rise to make room for the air. And, again, if the suspended vessel be counterpoised by a weight, so as to allow it to be a little heavier than the quantity of water which it displaces, it will descend if the entering gas be withdrawn through an outlet made in the vessel to permit the gas to escape. But if the outlet be stopped, and air again be admitted under the vessel it will rise again. The apparatus, therefore, is not only a reservoir for storing up the gas introduced into it, but serves to expel the gas which it contains, when required into the pipes and mains connected with this machine.

"According to this construction of the apparatus, the interior inverted vessel forms strictly what is termed the gas holder. It is suspended as already passing over pullies, supported by blocks and frame work, and to the chain there is affixed a counterpoise balance, of such a relative weight as to allow the gas holder a slow descent into the water, in order to propel



A REVOLVING RETORT OF INTERESTING CONSTRUCTION

the gas into the mains or vessel destined to receive it, with a very small and uniform weight. It will be obvious that when a gas holder of this construction becomes immersed in the water, it loses as much of its weight as is equal to the bulk of water which it displaces, and hence to render its descent uniform, and to preserve the gas within, of an invariable density, at any degree of immersion, a greater counterpoise is required as the gas holder rises out of the water.

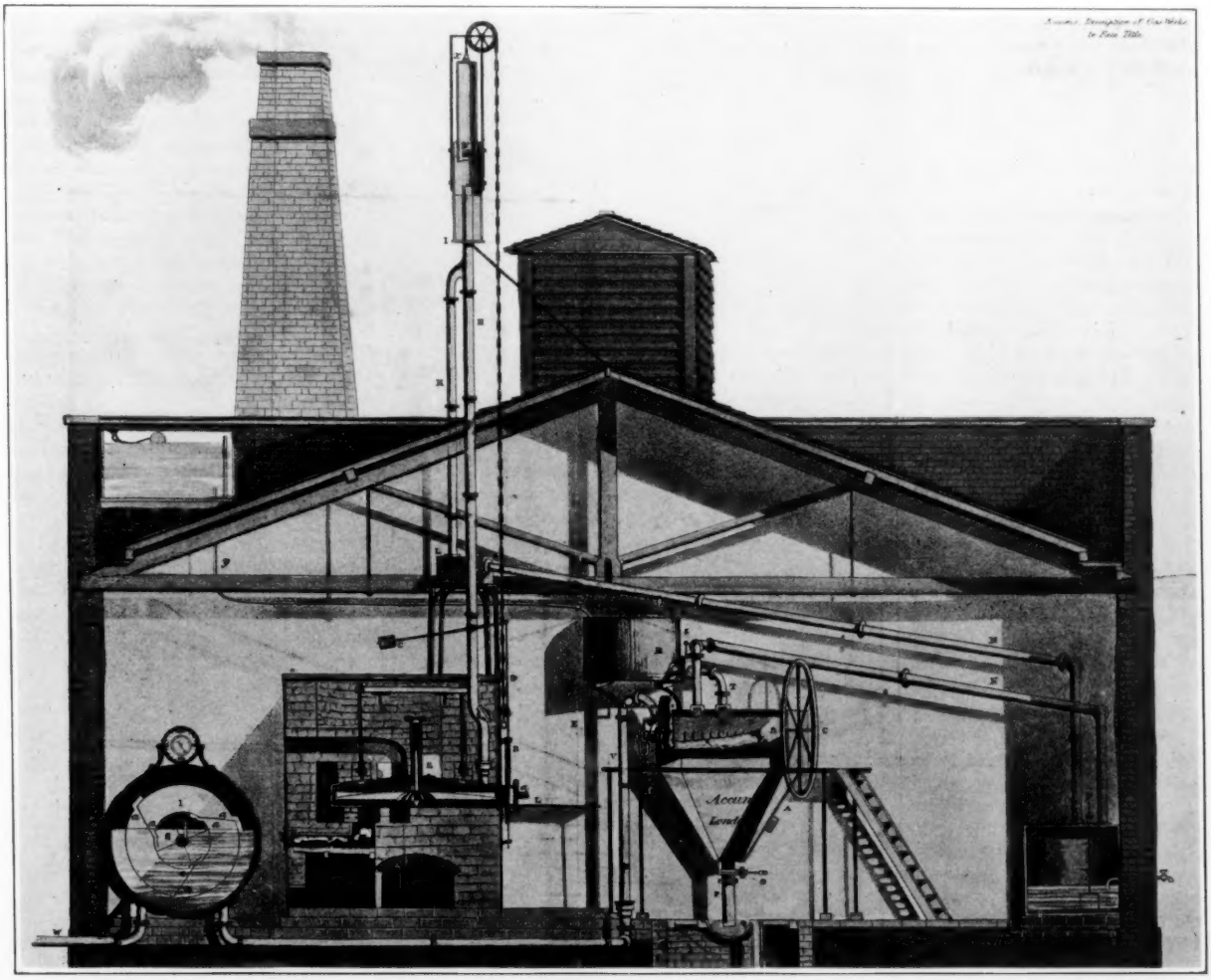
"It is obvious," continues our author, "that before the purified gas can be admitted into the gas holder, the vessel must be allowed to descend to the bottom of the exterior cistern in order to get rid of the common air which it contains. This may be effected rapidly by opening the manhole at the top of the gas holder, to cause the vessel to descend completely into the outer cistern filled with water. The manhole is then screwed up again air-tight, and the machine is ready to receive the gas. It is obvious that the operation of opening the manhole for letting out the common air requires only to be done once prior to the commencing of the working of the apparatus.

"The revolving gas holder is an ingenious contrivance invented by Mr. Clegg, for storing large quantities of gas. A

gas holder of this construction may be erected with advantage in situations where the nature of the ground will not admit of a deep cistern either above or below the ground being constructed, without an enormous expense. The base which it occupies is no larger than what would be required for a gas holder of equal capacity, built on a plan of the gas holders of which descriptions have been just given. It regulates its own specific gravity. And though more expensive in the construction, yet as it does not require a deep cistern, like the machines already described, it can be erected at the same cost. The revolving gas holder is shown. Its capacity is 15,000 cubic feet, it weighs twelve tons.

"The collapsing gas holder is a still further improvement by Mr. Clegg, on this part of the gas light apparatus, and certainly of all the contrivances which have been invented for collecting and storing up large quantities of gas, this machine must be pronounced to be by far the most simple, economical and efficient. The striking advantage of the revolving gas holder which we have just been describing, is that it enables the dimensions of the tank to be very much diminished, where the nature of the ground will not admit of a cistern of great depth being sunk, except at an extraordinary expense; but the still superior feature of the collapsing gas holder which we now come to describe is that it may be constructed of any required capacity, and adapted to a tank or cistern of such diminished depth as scarcely to deserve that name. It requires a sheet of water no more than eighteen inches in height, so that it may be constructed in or upon ground of all descriptions, not only with every possible facility but at an immense saving of expense.

"It is composed of two quadrangular side plates joined to two end plates meeting together at top in a ridge like the roof of a house. The side and end plates are united together by air-tight hinges, and the joints are covered with leather to allow the side plates to fold together, and to open in the manner of a portfolio. The bottom edges of the gas holder are immersed in a shallow cistern of water, to confine the gas. By the opening out or closing up of the sides and ends of the gas holder, its internal capacity is enlarged or diminished, and this variation of capacity is effected without a deep tank of water to immerse the whole gas holder in, as required in the ordinary construction of rising and falling gas holders. The collapsing gas holder requires therefore only a very shallow trough of water to immerse the bottom edges of the gas holder to prevent the escape of the gas introduced into it. The lower edges of the gas holder which dip in water are made to move in an horizontal plane or nearly so, when they are opened, so that they dip very little deeper in the water when shut or folded together than when opened out. For this purpose the top or ridge joints which unite the two sides of the gas holder, are slightly raised up when the sides close or approach together, or slightly depressed when the sides open out or recede from each other. To guide the whole gas holder in this movement, two perpendicular rods rise from the bottom of the shallow tank which pass through sockets in the ridge joints at the upper part of the gas holder. These sockets



AN EARLY INSTALLATION AT THE LONDON MINT; FROM LEFT TO RIGHT ARE SHOWN THE GAS METER, HORIZONTAL ROTARY RETORTS, THE PURIFYING APPARATUS AND THE TAR CISTERN

are secured by collars of leather round the shafts or rods, to prevent the escape of the gas, and they are braced by chains proceeding from their upper extremities and fastened at the ground on each side of the tank."

PART III.

Gas meters or "self-acting gages," as they were called, were early developed to a remarkable degree as were gas governors, gas mains and service pipes. The question of burners has already been referred to. We have now seen how the primitive plants were operated, and let us take a step ahead and see the condition of gas in London in the mid-Victorian period. We quote from an article of 1854:

GAS WORKS AND GAS LIGHTING IN LONDON IN 1854

"A convenient and cheap mode of obtaining artificial light is, in these latitudes, one of the greatest advantages that science can confer on the inhabitants of a large city. Those who remember the night appearance of London fifty years ago [*i.e.*, about 1800], when the dim oil lantern in the street, and the flickering candle in the shop window, served for little more than to render darkness visible, will the more readily appreciate the brilliant illumination now seen almost universally throughout the metropolis. The introduction of gas lighting has not only tended to improve the trade in the shops but has also had a most important influence in protecting property against the attempts of the robber, to whom the dark and lonely state of unlighted streets and roads has always given encouragement and shelter.

"Gas lighting is an invention of the present century, the first application of it, on any scale of magnitude, having been made by Mr. Murdoch, at Soho, near Birmingham, about 1802. A year or two afterwards Mr. Winsor, a German, exhibited it for the first time in London, and projected a company, to be called the National Light and Heat Company, for the purpose of applying the principle on a large scale. In 1807, he lighted one side of Pall Mall with gas; and having obtained subscriptions to a considerable amount, proceeded to try experiments, in which he expended the whole of the money subscribed; his supporters, however, nothing daunted, persevered in their attempt, and in 1809 applied to Parliament for an act of incorporation, to enable them more effectually and beneficially to carry on their works. They encountered much opposition, and their application was unsuccessful; but they returned to the charge and in 1810 obtained their act, which was followed on the 30th of April, 1812, by the grant of a charter of incorporation. This was the origin of 'The Gas Light and Coke Company,' more generally known as the Chartered Gas Light and Coke Company, the first established, and now the largest in London. Their first works were in Cannon Row, Westminster; but finding this site inconvenient, they removed to Peter Street, or Horseferry Road, where their principal establishment now stands. Their first trials on a large scale were very costly, as experiments of this nature must necessarily be; but in 1813 they engaged Mr. Samuel Clegg, whose name is connected with some of the greatest improvements in gas lighting, and soon after this time their arrangements rapidly improved."

THE FUNCTION OF HAEMOPORPHYRIN IN THE BLOOD

A WRITER in *Kosmos* (Stuttgart) in an article on Light as an excitor of disease mentions some curious and important facts concerning the function of one constituent of the coloring matter of the blood, *i.e.*, haemoglobin. He says:

We know today that nearly all fluorescent substances exert a sensitizing influence upon the organism and that those rays of light are most effective which excite the strongest fluorescence. It is very interesting, therefore, to learn that fluorescent substances are very widespread in the organic world and play a great part therein. Chlorophyl is a fluorescent green coloring matter which makes the tissue of plants sensitive to light and with the help of this substance the plants are able in some manner, still imperfectly understood, to produce starch and carbon dioxide and water. Careful tests have shown that chlorophyl is a true sensitizer. Infusoria placed in contact with a chlorophyl extract made from green leaves and then exposed to light quickly die, while if kept in the dark they exhibit no alteration. Red blood corpuscles when mixed with culture of infusoria quickly cause the organisms to die when exposed to rays of light.

Very recent experiments, too, have shown that in the animal organism also there exist fluorescent combinations which have been formed from haemoglobin, which we must remember is very similar to chlorophyl in many respects. These fluorescent compounds are called porphyrins and the most important of these is *Haemoporphyrin*.

Haemoporphyrin is a derivative of haemoglobin and is chiefly distinguished from the latter by its lack of iron. It is found in all normal urine, though only in traces, the amount increasing somewhat in cases of fever. Like its predecessor it has a strong sensitizing influence. When it is added to a culture of Infusoria the organisms quickly die when exposed to light, though they remain uninjured as long as they are kept in the dark. If a small amount of this substance is injected into a mouse, the animal remains quite healthy and lively as long as it is in the dark; but when it is exposed to the light (even merely to diffused daylight) the animal soon begins to scratch at the point of injection, grows restless and turns around and around, gradually becoming quieter until it becomes exhausted and finally dies.

THE REDUCTION OF DUST EXPLOSIONS AND FIRE FROM ELECTRIC LAMPS

FAULTY electrical installations and inadequate protection constitute a serious fire and dust explosion hazard in dusty industries, say specialists of the United States Department of Agriculture in Department Circular 171, A Recently Developed Dust Explosion and Fire Hazard. To prove that fire and explosions may be caused by electric lamps, the department specialists conducted a series of experiments in the laboratories of a large lamp manufacturing company.

All electric lamps in places where explosive dusts are present should, they say, be equipped with vapor-proof globes, protected by heavy guards to prevent breakage. Many of the dangerous practices, such as the use of open wiring, drop cords, unprotected lights, etc., can be eliminated by modern installation methods.

The bulletin states that explosions have occurred as a result of lowering into a bin an unprotected electric lamp attached to a cord. The lamp may swing against the side of the bin and if the globe is broken the hot filament in the lamp is exposed for an instant and the surrounding dust cloud ignites.

It is believed that any combustible dust, if allowed to collect on the lamp in sufficiently thick layers and remain long enough, will ignite. The ignition of the dust is probably due to the fact, the specialists say, that the very chaffy dusts collect on the globe where they form a blanket which prevents radiation of the heat generated in the lamp and raises the temperature of the bulb to the ignition temperature of the dust. Some of the dusts seem to melt or congeal and form on the globe a crust which does not burn readily. During the recent dust explosion prevention campaign about 20 cases were reported where explosion or fire was supposed to have been started by the ignition of dust which had settled on the lamp or by the accidental breaking of the electric lamp in a dusty atmosphere.

Under ordinary conditions, with the small lamps commonly used in industrial plants and with free circulation of air about the globe, the specialists believe it unlikely that fire will start readily. They recommend, however, that all electric lamps be equipped with vapor-proof globes. The straight-side, vapor-proof globe which prevents the accumulation of dust on the lamp may be used to maintain a low temperature. The use of drop cords and the so-called extension, or portable, lamps is probably the most common and objectionable practice and should be eliminated so far as possible.

Asbestos and What It Means to America

Where the Mineral Fiber Comes From, and Some of Its Applications

By Robert G. Skerrett

ASBESTOS was but a laboratory curiosity a comparatively few years back. Today, however, this unique mineral figures importantly in many of our daily activities, and we shall probably yet learn of more ways in which it may be made to serve us advantageously.

Asbestos is of divers kinds. Some have short filaments, others have long fibers, and there is a sort that has a strictly crystalline structure. Until recently the manufacturer insisted upon asbestos of a silky texture, and would have nothing to do with the type that was marked by longer but less flexible filaments. As might be expected, necessity has given industrial value to some of the hitherto unfavored varieties, but, even so, the preference still prevails for an asbestos which will lend itself readily to weaving or felting because of its pliant fibers. Canada supplies the world with the largest quantity of this particular kind of asbestos, known as chrysotile, and the United States utilizes by far the biggest share of this output.

According to the latest figures available, the asbestos mines of our neighbor to the north yielded, in 1919, a total of 135,861 tons of marketable asbestos, valued at $10,982,289, and of that amount we took quite 89 per cent. In other words we are in the lead as manufacturers of this material. It is true that asbestos has been found in Arizona, California, Georgia, Maryland, Oregon and Idaho. Georgia is the biggest producer, but it furnishes only fiber of the lowest grade. California ranks next, and, together with Maryland, is a source of a good quality of so-called mill fiber. Arizona at present is third in output, its asbestos being chiefly spinning fiber with a considerable proportion of the mill sort; but recent discoveries of asbestos of unusually long fiber and silky texture promise to give that State preeminence.

RAW ASBESTOS FROM THE QUEBEC MINES

Whatever may be the future development of our own resources, the system of mining the stuff will probably be much akin to that practised in uncovering the famous deposits which lie in the Province of Quebec and run, in the form of veins, through massive ledges of serpentine rock. Merely because the filaments of this asbestos may be separated from one another by the unaided fingers is no warrant for the assumption that the raw material can be recovered with anything like that ease from its prehistoric bed in the earth's crust. The mining of asbestos in Canada is, indeed, a toilsome undertaking; and for every ton of marketable asbestos a great many tons of enveloping and superposed rock must be removed. This can be appreciated when it is recalled that during 1919 a matter of 3,061,690 tons of rock was mined and taken out of the pits, from which was realized an average of only 100.8 pounds of asbestos per ton of serpentine.

Broadly stated, asbestos has heretofore been mined in open pits or quarries, and this procedure still predominates in the Province of Quebec. At the start, after exploratory borings have brought to light underlying veins of the mineral, the superposed soil must be cleared away, and this not infrequently calls for the digging by steam shovels of earth to a depth of 25 feet. With the asbestos-bearing serpentine thus exposed, then comes the actual excavation of the productive pit, and it is customary to cut and blast the rock in a series of benches, stopes, etc., which are dimensioned agreeably to the magnitude of the pit and the depth to which the work is carried. The rock so detached is then hoisted out of the pits by derricks or overhead cableways.

This serpentine is attacked by power-driven drills and the holes are next charged with dynamite containing 40 per cent of nitroglycerine. These operations demand wide experience and a pretty comprehensive knowledge of the trend of strata and sheeting planes. Otherwise much time and money can be squandered in fruitless efforts. The Thetford District of the Province, where most of the mining is done, is divided off into numerous claims, and competitive enterprises are often close neighbors. This situation has been responsible latterly for some variations in the general practice of getting out the desired asbestos.

For instance, at one mine, situated in a narrow strip between flanking claims, open-pit excavating had to be halted because the clearing had gone down to a depth where there was fear of the steep sides yielding and starting rock slides. Accordingly, the owners offset this hazard by sinking a series of shafts, and from these, some hundreds of feet below, they developed a system of drifts, galleries, glory holes, etc., similar to the features characteristic of hard-rock mining for copper, tin, gold, silver, etc. Normally, open-cut methods answer best and are the most economical, for the reason that the asbestos veins traverse the serpentine in an erratic manner, which makes subterranean mining uncertain and often unprofitable. But, as just explained, there are circumstances that have made it worth while to alter the long-established procedure in some radical particulars. Commonly, where the pit is of considerable depth and length, cableways are stretched across the excavation, and by these the rock is lifted to the surface and then conveyed to convenient dumping points. In the larger of the pits these steel lines span an interval of 400 feet and more. About three years ago some of the Thetford mines began to abandon the hoisting of the quarried material by means of these agents and adopted, instead, what is technically known as the "glory-hole system," which entailed the handling of the stuff by shaft. So well has this innovation worked that it is authoritatively declared that the method is likely to become the prevailing one hereafter.

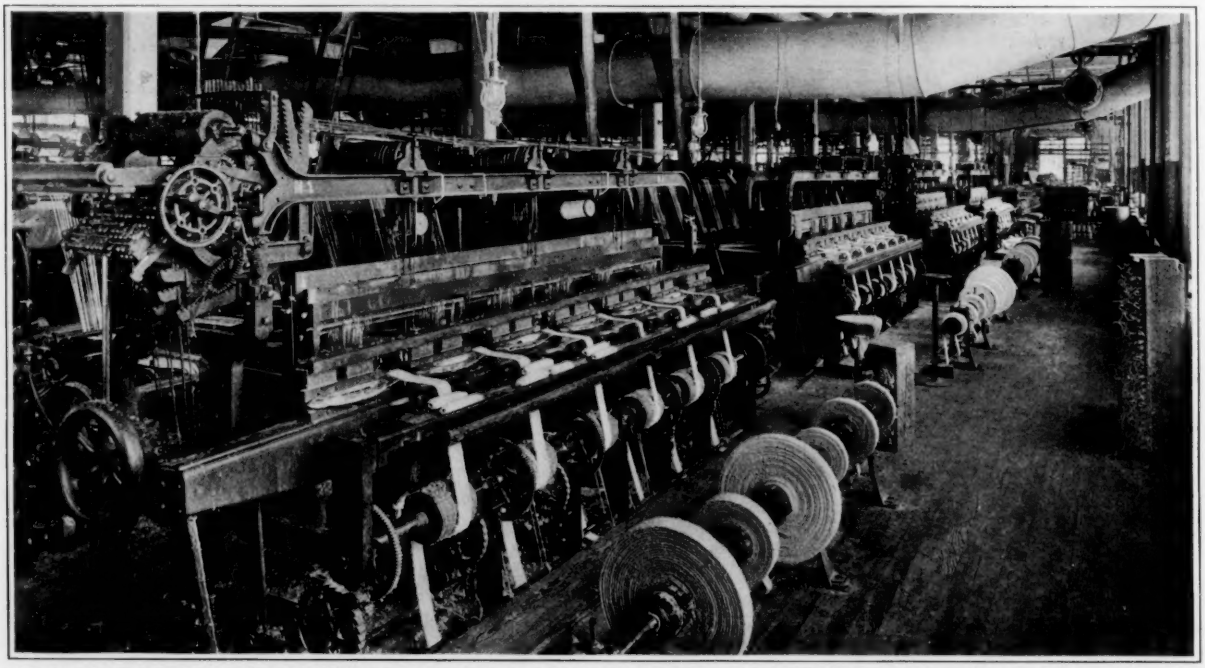
In a general way, the new practice is a wedding of open-cut and underground mining, or, to be more specific, the quarrying is done in the open, while the hauling of the blasted rock is below ground. The ore reaches the surface thence by suitable lifts installed in a main shaft. From the main shaft, which is sunk outside but near the glory hole, as the familiar quarry is called, are driven levels reaching far into the asbestos deposit, and from these levels radiate cross-cuts. The latter constitute points of departure for a series of smaller vertical shafts which rise until they break through the floor of the glory hole. Their uppermost terminals are funnel-shaped,

WHERE ASBESTOS IS TRANSFORMED FROM A SHORT MINERAL FIBER INTO A TEXTILE; MULE SPINNERS ON THE LEFT AND AT THE RIGHT, THE YARN ON BOBBINS READY FOR SPINNING

and into them the asbestos-bearing rock is dumped as it is mined. These "mill holes" are the mouths by which the mineral descends into chutes which, in turn, discharge into little mine cars traversing the cross-cuts below. Trains are then made up of these laden cars, which travel via the levels to the main shaft, where suitable connections are made with the hoisting equipment. Some of these shafts reach down to a depth of more than 500 feet.

After the ore has come out of the mine it is then subjected to dressing or "cobbing," *i.e.*, separating the asbestos fiber from the rock. Mechanical means are employed for this service save in the treatment of the higher grades of the stuff, such as Nos. I and II, where hand dressing is relied upon because it is possible only in that way to avoid the inevitable tearing of the fiber. The workers that do the cobbing are experts, and they skilfully break the asbestos clear from the serpentine by hammer blows. In the first dressing they use one-hand sledges weighing about six pounds, and the released fiber is screened from the shattered rock by 3/16th-inch mesh. The remaining ore is carried to a second cobbing shed, where most of the contained asbestos is freed by operatives equipped with lighter hammers. The resulting material is then screened twice to get rid of any adhering rocky particles and to separate the fibers into grades I and II. This asbestos is known to the trade as "crude." The refuse from the cobbing tables and the waste from the screens are next handled mechanically in a mill.

Mechanical cobbing is done by an apparatus commonly called the "cyclone." Briefly, the machine consists fundamentally of a strong metal casing that houses two oppositely revolving propellers, and these throw the pieces of ore at great speed against the enveloping walls or back and forth



THE MACHINES THAT MAKE ASBESTOS BRAKE-LINING FOR AUTOMOBILES, THIS FABRIC BEING COMPOSED OF ASBESTOS YARN INTERWOVEN WITH WIRE TO GIVE THE NEEDED TENSILE STRENGTH

upon the blades of the opposing rotors. In this way the serpentine and the fiber are broken apart. By an induced draft the comminuted rock and the fluffy asbestos are extracted from the "cyclone" and are next carried over a number of agitated screens, which segregate the fiber from the granulated or pulverized substance. A second suction system now gathers up the asbestos filaments and discharges them into settling chambers. In passing, it should be said that the original blocks of serpentine are reduced in size by one or more crushers, and that the average piece so prepared for the "cyclone" does not measure more than an inch and a half. Furthermore, the broken ore is put through rotary dryers to get rid of the moisture which would be apt to interfere with the releasing of the asbestos by the mechanical cobbers.

Inasmuch as the filaments are of various lengths when they reach the settling chambers, it is essential that they be assorted subsequently into the grades known to the trade. This is done by sifting the material through screens of different-sized mesh. With this work finished, the asbestos is packed in bags ready for the manufacture of all sorts of asbestos commodities. Asbestos not classed as crude, agreeably to the requirements already mentioned, is known as "fiber" or "mill" asbestos, and while this is not suited to spinning and weaving, as is the silky thread-like crude, still it is capable of being worked into a large number of useful forms.

In the years gone, when we first put asbestos to use, it was employed principally in sheets as a barrier against flame and to a lesser extent as a heat-insulating material. As time went on the durability of the stuff and its potential value in other directions became evident, and out of this realization has evolved an industry of considerable magnitude. Indeed, it is not overstating the case to say that we would be pretty hard put to it if we could not command the asbestos products now on the market. For architectural purposes we have today asbestos shingles, felt, mill board, flooring and paper; asbestos is worked into automotive equipment in the shape of tape, brake lining, packing, etc.; it is fabricated into insulation for boilers, piping, etc., and it is a prime constituent in refractory cements, various fireproofing compounds, and packing for divers mechanical uses where heat and acids have to be dealt with. Again, asbestos possesses a cloaking or protective quality of merit in confining cold or in shielding from the effects of low temperatures; and the stuff is utilized variously in electrical installations as an insulator and as a screening or sheltering blanket. In fact, asbestos is decidedly unique in combining the dual qualities of an insulator of both heat and electricity. A good grade of asbestos tape will stand a rise in temperature of 527 degrees Fahrenheit before a breakdown occurs and is proof against electrical puncture up to 250 volts. On the other hand, some asbestos goods will stand a temperature of 4000 degrees Fahrenheit.

Finally, to bring asbestos still closer to us, the manufacturers are now turning out wearing apparel in which this mineral is helpfully incorporated. That is to say, aprons, coats, gloves, overalls, shoes, and whole suits, with or without helmets, are now available. Most of us are familiar with the asbestos household articles, such as baking sheets, stove mats, table covers and pads, flatiron holders and the like. And then at the show, for our further security, there are theater curtains and booths for motion-picture machines of asbestos. All of these applications of asbestos are suggestive hints of possibly wider fields in which it may serve us in the near future.

As may be appreciated, asbestos fiber of the best "crude" is not as strong as many filaments of vegetable origin, such as cotton and flax, but, even so, manufacturers have succeeded in producing asbestos thread of sufficient tensile strength to answer admirably for numerous purposes. Threads of this sort are now made that weigh but an ounce per hundred yards, and these are woven into various fabrics. To prepare the fibers for spinning they are first carded and then condensed in a manner akin to the procedure in vogue in the ordinary textile plant. But, as might be expected, because of the dis-

HOW THE MINERAL FIBER IS FORMED INTO BOARDS AND SHEETS OF FIRE-RESISTING AND INSULATING VALUE

Left: In the pulping mill, where the asbestos fiber and the binder are thoroughly mixed by mechanical beaters, preparatory to being formed into sheets in the manufacture of insulating paper, mill board, etc. *Right*: The band-saws employed in trimming the edges of asbestos fire-felt blocks, lagging, and similar material

tinctive characteristics of asbestos, it has taken time and much experimenting to evolve machinery suited to the work.

The fiber is first formed into "slivers." These are coiled in cans and carried to the spinning department, where they are twisted into threads. Once brought to this state, the asbestos is then fit for weaving, and is next fed to the different apparatus which fabricate it into yarn, tape, or cloth, agreeably to the uses to which it is to be put. As will be readily understood, the yarns are wound upon bobbins and spools to facilitate the operations at the several machines. For certain commodities, where strength is an essential factor, wire and asbestos are woven together; and it is in this manner that brake-shoe linings, for instance, are manufactured.

The production of mill board, in which short-fiber asbestos is employed, is fundamentally a duplication of the course pursued in turning out pasteboard — in short, is analogous to paper-mill practice. The asbestos fiber is dumped into tanks, where it is subjected to the action of a rotary beater, and the stuff is pulped and mixed with the other ingredients that constitute the binding medium. The latter is commonly a type of hydraulic cement. When the pulp has reached a proper consistency it is discharged into a vat, where it is continually agitated until picked up by a screen which envelopes a rotating cylinder. From the cylinder the mushy stuff is transported by an endless belt to a set of metal rolls and is there pressed for the purpose of getting rid of a good deal of the contained water. Gradually, upon the upper of the two cylinders, are built up layers of the plastic material, and, when the accumulation is of sufficient thickness, it is removed from the cylinder by a single lengthwise cut.

When sheets of this nature leave the rolls they are placed in hydraulic presses between flat steel plates, where still more of the residual moisture is expelled. After a proper seasoning period this mill board or asbestos "lumber" is ready for distribution to the trade. The stuff can be sawed, cut, drilled and nailed easily, and is widely employed for paneling, for wainscoting, for ceilings and partitions.

Asbestos paper is manufactured from fiber ranging from that too short to measure up to filaments having a maximum length of half an inch. This stuff is known to the trade as "paper stock," and in producing the paper between 5 and 10 per cent of the composition is a binder which varies according to the use to which the finished article is to be put. The binder, which is needful to give the asbestos paper the desired tensile strength, may be starch, flour, cold-water paste, silicate of soda, etc. Lime answers well as both a cementing and a hardening ingredient. Generally speaking, asbestos paper is made along much the same lines as those pursued in the cases of heavy chip and box boards, and its preparatory treatment does not differ mechanically from that of asbestos mill board save, of course, that the sheets, formed on the pressure rolls, are much thinner. Asbestos paper is sometimes only one-hundredth of an inch thick and will then weigh about 3½ pounds for each 100 square feet.

Asbestos paper is very largely utilized in the forming of blocks and sheets for insulating ovens, ranges, oil and gas stoves, dry kilns, portable field kitchens, etc. It is also put as a lining in safes and other metal office equipment designed for the better storage of papers, documents, and records that would quickly perish if exposed to high heat or flame. Asbestos paper is now worked into the armatures of electrical apparatus as a medium for insulating the various parts from one another. And, latterly, a form of asbestos paper has been made that is being fashioned into mail bags for the aerial postal service. Manifestly, this is a precautionary measure intended to protect the mail matter from fire should the planes come to grief through leaky fuel tanks or a conflagration following a disastrous landing.

It is unquestionably true that asbestos shingles, asbestos roofing, and asbestos weather board minimize fire hazards; and extensive experience has demonstrated that buildings have gone up in smoke and flame while those exposed to the same peril but shielded by these asbestos materials have escaped. The wooden shingle is all too frequently tinder to the wind-swept spark, while the asbestos shingle or roofing is immune to this menace. Not only that, but the asbestos shingle has a long life; and both the shingle and the slab or corrugated roofing are unaffected by the weather and by any acids that may be carried in the atmosphere.

Asbestos cement is a commodity that is steadily growing in demand, and it is widely used as an insulation against heat. Asbestic, which is composed of the more minute particles of asbestos, is applied to walls and ceilings as a plaster and, of course, minimizes the effects of flame and cold. On account of the progress in the art, asbestos, whether of the classes termed "crude" or "fiber," can be worked up in some manner to give it marketable value and to fill a want. This has reduced to a minimum the waste of the mineral when once the stuff is mined. Manifestly, it behooves us to open up the deposits of asbestos within our own boundaries wherever the quality warrants exploiting; and there is reason for the belief that some of these veins give promise of yielding large quantities of superior sorts. From a curiosity asbestos has become a necessary commonplace, and American inventiveness and mechanical cunning have achieved this in but a few years.

Ultra X-Rays and Cosmogony*

The New Theory of Radioactivity and Its Bearing on the History of the Stars

By Jean Perrin

LET us imagine for a moment that we, ourselves, are making such a voyage that we are at least able to observe in every detail that which is occurring upon the Moon, for example, or upon Venus or Jupiter. We should certainly expect to find novel sights spread before our eyes, but among the most important changes, implying the most profound differences, even in phenomena, which at first glance appear to be entirely independent, perhaps we should have to place those changes which we should find in the phenomena of radioactivity.

There is no reason, in fact, why the Ultra X-rays issuing from the planet should be exactly similar to those upon the earth. It seems quite possible that not only their average intensity but their relative proportion in function of frequency would have changed. In a word we may assume that each planet has its own particular "spectrum" of Ultra X-rays in accordance with its size, with the thickness of its solid crust in case it possesses one, with the activity of its internal fires and with the degree of evolution of the materials of which it is composed. Thus the average lives of the radioactive elements would not only differ from their lives upon the Earth, but they would not be in the same ratio; even the order of the various kinds of radioactivity would change, perhaps—a given element which was more durable upon the Earth becoming less so elsewhere.

Possible Evolution of Life.— And when we recall that our radioactive bodies exert a profound effect upon living cells and especially upon the phenomena of cellular division, the thought occurs to us that possibly our Ultra X-rays may have an influence upon the evolution of life.

*Translated for the *Scientific American Monthly* from *La Revue du Mond* (Paris), for Feb. 10, 1920.

Perhaps upon some other earth similar to our own, but emitting different kinds of Ultra X-rays, the same sort of living creatures are not able to exist in the form we know and must either adapt themselves through modification to their environment or disappear. Thus each of these planets which were indeed deified by the ancients, may have its own secret personality—a nature perilous to the visitor from afar.

In the vicinity of the sun or of the stars the magnitude and the order of the various kinds of radioactivity would doubtless be still more profoundly altered. There, for example, radium could be only a fugitive element imperceptible in our spectroscope. Likewise we may conceive that such an element —unstable at the surface of the stars—might be found in considerable proportions in cosmic conditions so different, wherein, indeed, the characteristic spectral rays of nebulæ reveal to us the existence of those atoms to which the name of nebulium has been given, whose weight places them between those of hydrogen and those of helium (Buisson and Fabry). One might have expected by reason of the low density which results to find these atoms of nebulium, like hydrogen and helium, in the upper strata of the solar atmosphere, and if they are not found there perhaps the reason is that they have been disintegrated (into hydrogen?) by the Ultra X-rays which traverse this atmosphere (or again, perhaps it is because they have been captured to form constituents of the atoms not broken up by these rays).

THE REGENERATION OF RADIUMS AND THE FORMATION OF HEAVY ATOMS

In indicating the conditions under which one might hope that radium may be regenerated at the expense of radon and of helium I have left the reader to guess the regions where I supposed this regeneration to be possible. Just as it is necessary to heat ozone to a high temperature in order to hasten its transformation into oxygen, in the same way the action of a temperature truly enormous will here be necessary to provide in sufficient quantity the regenerating radiations, less penetrating than the Ultra X-rays, but certainly still of very high velocity frequence.

But these regions of the universe in which the temperature is actually enormous are quite well known to us. Without going any farther to begin with under our very feet, within the deeper strata of this terrestrial globe, it is probable that light atoms of the hydrogen type are combining with each other to form heavy atoms of the radium type, at the same time liberating in the form of Ultra X-rays a formidable amount of energy which is utilized in supporting the central fires. Some of these Ultra X-rays even arrive at the cold strata of the surface, and it is these rays which produce within the few heavy atoms these strata contain, the phenomena of radioactivity which strike us as being so remarkable. It is entirely a secondary phenomenon: the principal transformation is effected in the first stage: *i.e.*, the production of heavy atoms.

ORIGIN OF SOLAR HEAT

Thus the light atoms, upon coming to approach each other sufficiently close (under the enormous pressure exerted by the deeper strata) and being subjected to an intense heat will produce heavy atoms, while liberating during the process an amount of energy immensely superior to that which sets the reaction going. This phenomenon, which is at bottom, that familiar in all forms of combustion (since it is necessary to "ignite" carbon before it will burn) seems to me to furnish an adequate explanation of the source of the sun's fires.

We are well aware of what a prodigious radiation the sun throws off into space without any apparent exhaustion and without any known form of compensation—an amount which would suffice to melt every second a cube of ice having an edge 1,000 km. in length. It appears that the origin of this enormous expenditure of energy is not to be found in chemical reactions; the most violent ones that we know of would scarcely suffice to maintain the fire of the Sun for more than a few thousand years—it would be a period of only 2,000 years in the case of a Sun made of carbon and oxygen. Lord Kelvin has pointed out that the condensation of the primitive nebula (the fall toward the center of the constituent particles) under the sole action of gravitation would constitute a far more important source of energy. The energy of gravitation thus consumed in the formation of the Sun would correspond (so enormous is it!) to about 30 million years of actual radiation. And it is necessary, says Kelvin, that geologists should content themselves with this period of time.

But they do not so content themselves. For the history which tells us of the strata slowly deposited at the bottom of the seas and containing fossil detritus very similar to those organisms which still exist can scarcely permit us to believe that the earth and the sun have undergone any very great amount of change if indeed they have changed at all, for a billion years. Moreover, we can see no sign of any approaching change close at hand. The theory is insufficient, therefore.

EVOLUTION OF THE STARS

We can remove this difficulty by our present theory. Let us imagine that the infinitely minute particles of dust or the isolated molecules which form the primitive nebula more or less analogous to that of Orion, are composed of very light atoms such as those of hydrogen, of nebulium or of helium.

In hurling themselves against each other, at the velocity which they have perhaps already had in coming from afar or that they have acquired in falling toward the center of the nebula, these particles liberate heat; and the mean temperature rises by many degrees (12,000 deg. in the nebula of Orion, according to Fabry and Buisson). Thus, on the one hand, since the nebula is contracting the conjunctions between light atoms capable of uniting to form heavy atoms must become more and more numerous and, furthermore, since the temperature is rising the intensity of the radiations which are capable of causing these unions must continually increase. For this double reason the formation of heavy atoms will become very considerable, growing more and more important and accompanied by Ultra X-rays which, for the most part, do not issue from the star whose temperature becomes enormous: *The star is ignited.*

This ignition takes place through a mechanical process which is definitely comparable to that which starts the combustion which takes place in a brasier when the latter is raised to a high enough temperature. It is this which served to occasion the liberation of heat considered by Lord Kelvin and due to the condensation of the nebula. And we can easily understand from our study of the energies exhibited in radioactive transformations, that the mass of the sun can easily maintain its radiation at the present rate for several billion years and, perhaps, for many, many billions. To sum the matter up we thus return to the ancient idea of a combustion, but in this case our concern is not with a combustion in which the atoms barely penetrate each other as in the formation of carbon dioxide, but with a profound penetration which mingles with each other in a far more intimate fashion, the atomic nuclei. This is the formation of the heavy atoms (of the radium type) at the expense of the light atoms (of the hydrogen type), or better still it is the disappearance of electrical potential energy and not of the energy of gravitation which causes the prodigious lavishing expenditure of stella radiations. This enables us to understand how the error committed with respect to the sign of the variation of energy which accompanies the radioactive transformation rendered inexplicable a problem which is really quite simple.

During this spontaneous combustion of the star the radiation will pass through a maximum and will then decrease; the superficial layers will cool off and, finally, a solid crust will form at once protecting the star almost completely against continued cooling. Having become similar to our own earth, this star, where the atomic condensation slowly comes to an end, will travel through space, during a period of time which will possibly be enormously long compared to that during

which it was refulgent. Sooner or later, however, it will clash against another star—one still shining perhaps, but more probably one already extinguished. If the comparative velocity of the two stars, while they were still at a great distance from each other, were of the magnitude of 50 km. per second, as is the case ordinarily in the Milky Way, it would be much greater at the moment of the shock—becoming 500 km. per second by reason of the acceleration produced by gravitation.

We have just seen how impossible it is to believe that the force of gravity alone can suffice to really rejuvenate these stars which crash against each other in the heavens. In order to secure this rejuvenation so that the cycle may be completed, as Arrhenius has conceived and set forth in his beautiful treatise upon cosmogony, it is necessary, above all, that there should be some mechanism in operation whereby there may be recuperated the enormous flux of energy which streams forth from the stars, and nothing comparable to which returns to them. (What would happen, for example, if the velocities of interstellar shocks were of the order of 20,000 km.-sec., which does not occur in the portion of the universe which we perceive? In order for this to happen, it would be necessary, in my opinion, for the cosmic dust driven afar by radiation, to have definitely transformed into kinetic energy the entire radiation of the stars.)

A space sufficiently great to accommodate this sort of recuperation would function as a medium absorbing light; this amounts to saying that beyond a certain distance the stars would no longer be visible. The remote *Galaxies* which we perceive, at a distance perhaps of 100,000 light-years, far beyond that Milky Way which surrounds us, suffice to prove that if such a recuperation occurs, it demands, at all events, a space enormously more extensive than the space which our telescopes have been able to penetrate.

Furthermore, it is in no way certain that the universe is to be regarded as a static state of equilibrium in which matter and light pass through a cycle whose majestic ensemble can be grasped by our finite minds. It can not be denied that within the most far-extensive limits wherein we can either know or divine the nature of this universe, we observe that it is a state of evolution, and is not remaining stationary. And if we confine ourselves to the sole fragment of evolution which we are able to grasp—of the period before and after which we know nothing—we must limit ourselves to the declaration that during a period of something like a trillion years matter must have passed from a nebulous state, in which it consisted of atoms of light weight, into a state of heavier and heavier atoms, grouped in larger and larger stars. Meanwhile a prodigious torrent of light has disappeared into infinite space.

The Perfume of the Orange

The Neroli Oil of the Riviera and Its Place in Commerce

THE flowers of the bitter orange and of the sweet orange can be distilled in the same manner as are roses. The former yields an extremely choice perfume known as orange flower oil or neroli oil, the perfume obtained from the sweet orange is called neroli-Portugal oil and is much inferior. All along the charmingly picturesque French Riviera the bitter orange is especially cultivated for the purpose of distilling perfume from its blossoms and leaves.

The oil is at first nearly colorless, or with but a faint yellow tone, but when kept it becomes reddish-yellow eventually. It is very limpid, but when seen in a clear glass has a bluish opalescent tone. The taste is somewhat bitter and the odor, while strong, is very delightful. Its specific gravity ranges from 0.85 to 0.90. While but slightly soluble in water it imparts a pleasant fragrance to the latter; orange flower water is colored red by sulfuric acid.

When 1 to 2 parts of 90 per cent alcohol are added to the oil, a clear solution is obtained; when more alcohol is added this solution becomes turbid and after being allowed to stand stearoptene separates from it in flakes. Unless kept with great care the oil becomes darker in tone and even unpleasant in odor. However, when thus injured it can be rectified with water. Since neroli is very expensive, it is, like rose-oil, much subject to adulteration; in fact, one cynical authority asserts that there is absolutely no genuine oil on the market and that what is known as pure neroli oil consists, on an average, of one-eighth part oil of bergamot and three-eighths of petit-grain, with only 50 per cent of the real neroli. A simple test for pure orange flower oil is to pour 1 or 2 drops upon sugar and then stir the sugar in water. If the oil is adulterated the water has a bitter taste. A test of more precision is to mix three drops of the oil with 40 to 50 drops of alcohol in a test tube and when entirely dissolved to add about one-third the volume of the whole of concentrated sulfuric acid. The solution of oil and alcohol is then mixed with the acid by a careful shaking of the test tube. If the oil is pure the resultant mixture will be turbid and either reddish or dark brown (the latter if the oil is old); almost all other oils used for adulterants give paler colored mixtures.

The odor of orange flowers is due to the presence of two volatile oils, one of these has a much more delicious odor than the other and it is this which is soluble in water, hence the somewhat faint but very agreeable fragrance of orange flower water. The other volatile oil is also fragrant and is sparingly soluble in water, but its perfume is much less delightful. The neroli oil of commerce consists chiefly of this second oil, and this is why the best orange flower water cannot be prepared by saturating water with neroli oil, but is obtained as a by-product in distilling the oil.

Neroli is in great demand in the manufacture of the choicer kinds of perfume, being a necessary constituent, indeed, of eau de cologne. It must be carefully kept in a dark place and protected from air and is not "ripe" enough to use until it has been stored for at least a year; but if it becomes too old it tends to become rancid, though this may be prevented by mixing it with an equal volume of fine spirits of alcohol.

The process of maceration or infusion is employed for flowers with but little volatile oil or whose odoriferous substance would suffer decomposition or adulteration by distillation. The process is founded on the affinity of odoriferous substances for fatty bodies which, when impregnated with them, are called *pomades*. These are afterward made to yield the aroma to strong alcohol, so that finally there is obtained a solution of the volatile oil in alcohol from which the pure oil is obtained by distilling off the alcohol. The fat used, olive oil, lard, etc., should be entirely neutral, *i. e.*, free from every trace of acid. The fats are purified by treating them in the heat with weak soda-lye and then washing carefully with water until the last traces of the lye are removed and the fat shows no alkaline or acid reaction.

With the use of olive oil the so-called "*Huiles antiques*" are obtained, which are merely solutions of volatile oils in the fixed oil. By the use of lard, etc., the genuine *pomades* are obtained, which are directly used as expensive articles of perfumery, but in the factories serve as a starting point for the preparation of volatile oils.

The old process of maceration, which is still in use in some parts of France, is as follows: A certain quantity of fat is

placed in an enamelled iron or porcelain pan provided with a water or steam bath. When the fat is melted, the freshly gathered flowers from which the aroma is to be extracted are thrown in and left to digest for from 12 to 24 hours, the fat being kept fluid and stirred frequently. When the flowers are completely exhausted, the fat is strained from them into fresh pots, in which it is again macerated with fresh flowers as before. This operation is repeated 10 to 15 times until the pomade has acquired the desired strength.

Experience, however, has shown that volatile oils prepared for this process possess a finer odor the shorter the time the flower remains in contact with the fat. Piver has devised an apparatus which reduces the time of maceration to the shortest period possible.

Maceration is employed for the flowers of the orange (*vitrus aurantum*) of the mock orange (*Philadelphia coronarius*), of the acacia (*acacia Farnesiana*), of the violets (*viola odorata*), of the mignonette (*reseda odorata*), etc.

The process of *absorption*, or "*enfleurage*," is it is called by the French, is chiefly made use of for procuring the odoriferous principle of very delicate flowers, the delicious odor of which would be greatly modified, if not entirely spoiled, by the application of heat. The older apparatus employed for the purpose consists of a number of shallow wooden frames of about 15 by 18 in., inclosing at half their depth a sheet of glass. The edges of the frame rise about an inch above each surface of the glass, and, being flat, the frames stand securely upon one another, forming often considerable stacks. These frames are called "*chassis*," those just described being termed "*chassis aux vitres*," or "*chassis aux pomades*," to distinguish them from a different form, which is used where oil has to be submitted to the process of absorption. The process in the case of pomade is as follows: Each sheet of glass is uniformly coated with a thin layer of purified grease, care being taken that the grease does not come in contact with the woodwork of the frames. The flowers are then thinly sprinkled, or rather laid, one by one, upon the surface of the fat, where they are allowed to remain one or two days, when they are removed and replaced by fresh ones. The operation is thus continued for 25 or 30 days, until the fat is saturated with aroma. The frames charged with fat and flowers are stacked one upon the other, forming, in fact, a number of little rectangular chambers.

PICKING ORANGE BLOSSOMS FOR THE PERFUMERY TRADE

For *perfuming oils* a metal sieve is substituted for the glass plate. Upon the sieve a piece of thick cotton cloth saturated with oil is laid, and upon this the flowers are scattered. The operation is repeated until the oil is sufficiently impregnated with aroma, when the cloth is subjected to pressure and the expressed oil filtered.

This process is very tedious, requiring much labor and a long time for the impregnation of the fat or oil, but, notwithstanding its faults, it is still pursued to a great extent, some French firms using 3000 such frames during the season.

The picturesque little town of Grasse, in the south of France, is the center of the perfume industry. For all perfumes except those of the rose and the orange the same process is employed; but tese two stand out as arts in themselves.

REINFORCED CONCRETE IN THE LIGHT OF GEOLOGY

A GERMAN officer, Major W. Kranz, connected with the Geological Institute at Würtemberg, calls attention in *Die Umschau* (Frankfurt) for April 23, 1921, to the inadequate attention which has hitherto been paid in tests of concrete to the character of the crushed stone employed in its production. He states that in the early part of 1917 he first pointed out that geologists should be employed to test the stone used in making concrete with respect to its hardness, its granular nature and any impurities such as loam or clay which it might contain.

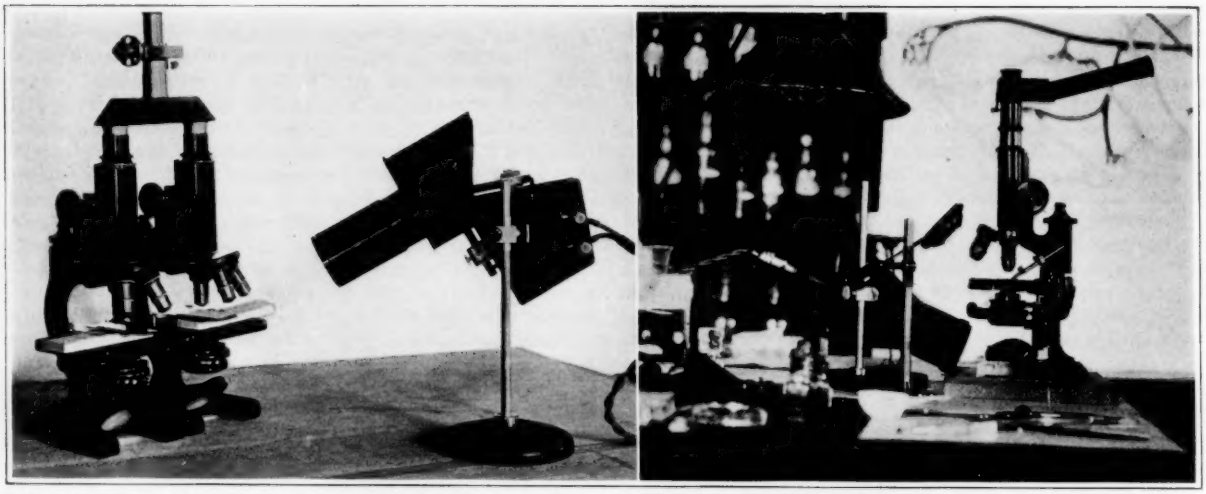
Special experiments were made to determine what kinds of stone and what mixtures were particularly well fitted for making reinforced concrete of a bomb proof character. Since reinforced concrete of great strength is not only useful for military purposes but for such peaceful enterprises as the building of canals, sluices, bridges, tunnels, etc., it is worth while quoting Major Kranz's conclusions, which are as follows:

Smooth pebble-stone or pebbles were even after a lapse of 28 days usually faultily incorporated in the concrete. Unfavorable petrographic qualities in the rock markedly decreased the firmness of the concrete made from it. Unduly large amounts of loam and marl in the sand and gravel employed betray themselves in broken surfaces of the concrete through deposits of finely divided loam and by lumps. A small amount of marl or loam, on the other hand, did not injure the concrete; in general loam and clay had a worse effect upon the resistance to pressure possessed by the concrete than equal amounts of marl. Flints or cheil in gravel sand become well incorporated with the concrete and do not injure its quality. Stream deposits rich in chalk are disadvantageous because of the softness of the stone, unless mixed with a certain amount of hard stone, in which case the concrete is improved.

As broken and chipped stone lime-stone of different geologic origin exhibited a very various degree of resistance to pressure in the form of concrete. Variegated or "new red" sandstone proved on the whole to be rather ill-fitted for the purpose of making concrete.

Fresh hard-stone, in the form of broken stone and chipped or flaked stone was found excellent—it could also be used at times in the form of crushed sand; sometimes, however, when thus finely crushed it was found to contain an undesirable amount of dust, even after it had been well washed. Weathered slag-stone from quartz-porphyry proved to have too low a degree of resistance to be useful in making concrete. Much weathered coal slack of porphyry granite cannot be used in making concrete when great strength is required in the latter.

No general rule can be formulated with regard to this matter because of the great variety, which exists among the materials found in nature. But on this very account, whenever reinforced concrete is to be used in important constructive work, it should be subjected to careful tests both previous to and during its employment by competent technically-trained geologists. It is necessary therefore that such a geologist should have personal intercourse with the officials, foremen, and workmen engaged in the various operations.



SOME OF THE APPARATUS USED IN THE TESTING OF FURS AND FABRICS, TO DETERMINE DURABILITY AND GENUINENESS

Left: Two microscopes fitted with the comparison ocular, with blocks from the attritiometer in place. *Right*: A microscope utilizing the highest powers, for the examination of individual hairs

Durability of Furs and Fabrics

Recent Methods of Determining the Resistance to Wear of Fur and Fabric Hairs

By Leon Augustus Hausman, Ph.D., Cornell University

WHAT is it which gives to furs their different wearing qualities? Some furs are notably poor in such qualities, while others bear a reputation for durability. In fabrics, too, there exist well-known differences in resistance to ordinary wear. Sometimes, no doubt, these differences bear a direct relation to the processes through which the animal hairs which make up the fur or fabric have passed while being prepared for the market. But, as a rule, the durability characteristic of furs and fabrics is determined by the structure of the individual hairs, and particularly, the writer believes, by the cortex element in each hair-shaft.

Fig. 1 shows a typical mammal hair, much magnified. It will be seen that the hair is composed of: the *cuticle;* an outer layer of flat, scaly cells, overlapping each other like the scales of a fish; the *medulla*, a central pith-like structure built up of piles of cells and arranged in various ways in different species of animals; and the *cortex*, or rigid and solid portion of the hair-shaft, composed of elongate, fusiform, horny, glassy cells, which have become fused together into an almost homogeneous mass. It is this latter element which gives strength to the hair. The greater, in proportion to the medulla, the cortex, the greater the resistance of the hair to wear.

The medulla, on the other hand, is an element of weakness in the make-up of the hair-shaft, for this structure is composed of empty, or nearly empty, cells, often with loose strands of elastic substance ramifying between them. Hence, if this element is great in proportion to the cortex, the hair becomes, in effect, a nearly hollow cylinder, which is easily broken. Microscopic examination of worn hairs shows that fur hair possessing a large medulla does, in fact, break up in just this way. (Figs. 2, 3.)

An examination under the microscope of fur-hairs from various species of animals will often yield sufficient data, concerning the size and structure of the medulla and cortex ele-

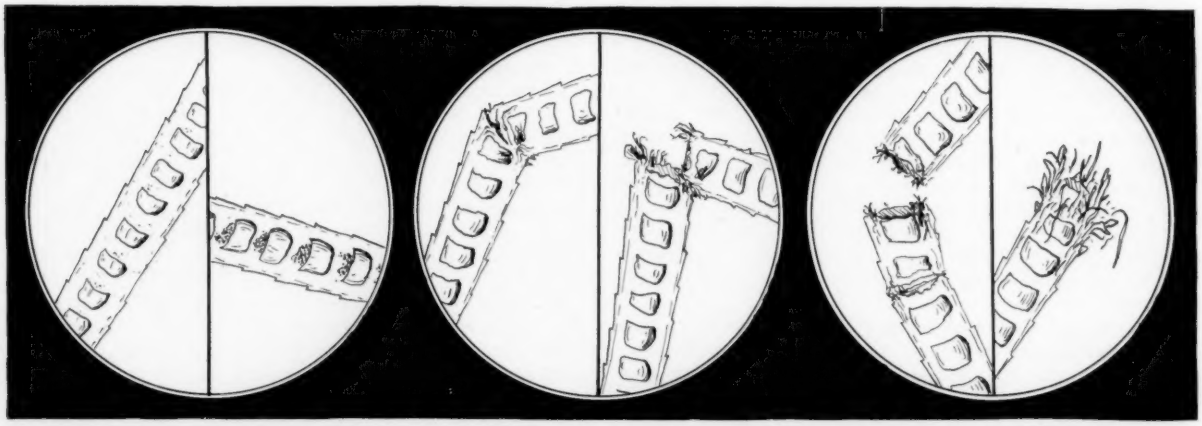


Fig. 1. Fur hairs of the gray Flemish rabbit (left) and the New Zealand red rabbit (right), seen in the comparison ocular

Fig. 2. Earlier stages in the break up and subsequent progressive wear of the fur-hair of an ordinary rabbit

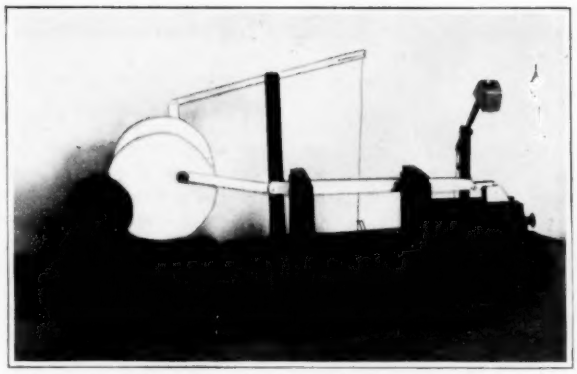
Fig. 3. Final steps in this distintegration, which is characteristic of fur hairs from the majority of fur-bearing animals

TYPICAL RESULTS OBTAINED BY DR. HAUSMAN WITH THE INSTRUMENTS AND METHODS DESCRIBED IN THIS ARTICLE

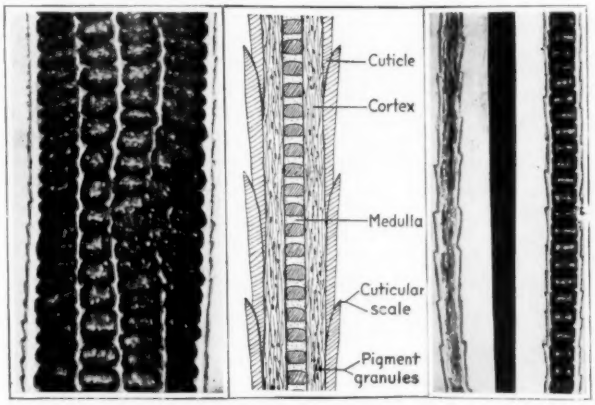
ment to make possible an evaluation of the probable wearing qualities of the furs. In Fig. 6 are shown photomicrographs of two fur hairs of vastly different wearing qualities. The fur hair of the American Otter represents one of the most durable of all the furs, being taken as 100 in the general estimate of relative fur-durability. In practically all of the fur hairs of this species the medulla is absent, the dark streaks seen in the hair being the masses of the pigment granules, which give the color to the hair. This means that the entire hair-shaft is a solid, almost homogeneous horny, elastic rod, well adapted to withstand attrition. At the opposite extreme, in durability, stands such a fur as that from the mole. A single fur hair from the common European Mole is shown in Fig. 4, at the right. This fur is usually rated between 5 and 7, on the basis of 100, in durability. A glance at the size of the medulla will show why. The hair-shaft is practically an empty tube, and can be easily broken.

What happens when a fur hair is broken can be seen in Figs. 2 and 3. As soon as the protective covering of the cuticle, or outermost integument of the hair-shaft is removed, the fusiform cells composing the cortex begin to fray, or sliver out, and the speedy disintegration of the hair-shaft is the result. In hairs possessing a large medulla this initial break-up occurs much sooner than it does in hairs possessing small medullary columns, or none at all.

Most mammals possess two distinct types of hair; a long, rather rigid type, known as the protective, or over-hair, and a shorter, finer, softer, more thickly compacted type, known as the fur, or under-hair. Where the protective hair is left in place, in the make-up of furs, the durability of the fur as a whole is not interfered with. But often this protective hair is removed. A much softer fur is the result. Since, however, the protection of the stiffer hair is no longer present, the wear on the fur hair directly soon makes its effect apparent. Often the protective hair is relatively, and also actually, more resistant to wear than is the fur hair underneath, by reason of its possession of a greater expansion of the cortex element in the shaft. In many other instances, however, the reverse is the case, and the protective hair, while actually more durable than the fur hair, is not relatively so. Fig. 4, taken from a photomicrograph of a portion of the protective, or over-hair, of the common gray rabbit, shows the enormous enlargement of the medullary element in the hair-shaft, and the extremely thin cortex. Such a hair is easily bent and broken. Fig. 1 shows the fur hairs from two common rabbits much used in the fur trade, with their large medullas. Rabbit and hare furs, as one might expect, rank relatively low in the durability scale, always below 10 (otter fur taken always as 100).

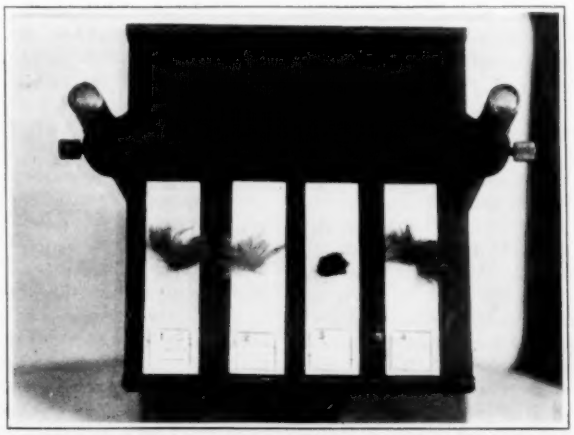


THE ATTRITIOMETER FOR DETERMINING THE RELATIVE DURABILITY OF DIFFERENT KINDS OF FURS AND FABRICS



TYPICAL MAMMAL FUR-HAIRS, SHOWN IN SECTION AND BY PHOTOMICROGRAPH

Left: Fig. 4. Photomicrograph of a portion of one of the long protective over-hairs of the common gray rabbit, showing proportion of medulla (the large ovoid cells) to cortex. Such a hair breaks more easily than one with smaller medulla. *Center*: Fig. 5. Typical mammal fur-hair, showing structure. It is the cortex element, with its strong, horny elastic cells, that gives resistance to wear. *Right*: Fig. 6. Two fur-hairs of different wearing qualities, showing how absence of medulla strengthens the hair. At the left we have a fur-hair from the American otter, very durable; at the right one from the European mole, a very weak and easily wearing fur



FOUR SAMPLES OF FURS MOUNTED ON BLOCKS, READY FOR TEST WITH THE ATTRITIOMETER

There is a slight variation, however, in the resistance character of the cortex in different species of the fur-bearing mammals. This variation is probably due to the quality of the keratin, or horny substance which composes the cortex cells, or to the length of the cells, or to their degree of fusion. It is not sufficient, therefore, in attempting to grade furs on the basis of their durability, to rest content with a microscopic examination alone, though, as has been pointed out, such an examination will reveal much.

In order to determine accurately the resistance of various fur hairs to a wearing process which could be kept constant for each variety of hair, or varied in accurate measure, the writer devised the Attritiometer (wear-measurer) shown on this page. Samples of fur to be tested are taken from various portions of the pelt, and mounted on blocks, as illustrated. These are then clamped in place on the block at the extreme right of the Attritiometer, and in this position are subjected to rubbing backward and forward by horizontal slide, and to beating by the hammer (shown upraised). The force of the blow delivered by the hammer is known (in grams), as is also the weight of the horizontal slide, which is covered with belt-leather of uniform texture throughout. The mechanism is operated by an electric motor (shown at extreme left).

The duration of the test for each sample continues until

the protective hair breaks, and the cortex begins to fray out. This is the initial stage in the disintegration of the hair, and can be conveniently taken as the stage when we can say "wear" begins. The test may be continued until the same stage of disintegration is reached in the fur hair.

In determining the stage at which the test shall be stopped the samples are removed from the Attritiometer and examined under the medium powers of the microscope, by reflected light, *i.e.*, light reflected through the microscopic tube, by the objects under examination themselves, as shown at the left of our opening view. The light must be rather intense, hence the use of the small microscope arc-lamp. For the more careful examination of the individual fur hairs the writer has used the apparatus shown in the right-hand photograph.

From a combination of microscopic examination of the cortex and medulla elements in the structure of the hair-shaft, and of tests of the hairs in the Attritiometer a much clearer idea of the reasons for the durability differences in fur- and fabric-hairs is being acquired. It is now possible to rate the durability of the different fur hairs on an accurate basis.

One of the striking results of Attritiometer tests is the way in which there is shown the superiority of the unclipped over the clipped fur, or over the hairs used in textile work. In the case of the unclipped hair, no portion of the cortex is exposed to wear and to the more rapid disintegration, until after the breaking of the hair occurs, or until some portion of the protecting cuticle is actually worn away. Disintegration, in such a case, then, is much delayed. With the clipped hair, on the contrary, the cortex cells are already exposed, *before actual wear on the hair commences.* Disintegration of such a hair, therefore, begins at once, the cortex fraying, or slivering as shown in Fig. 3 (right).

Tests of furs with the Attritiometer, together with subsequent examination under the microscope, have also shown that the identification of imitation furs can be, in some cases, readily made, on the basis of the different methods of disintegration which different species show. This may prove to be a valuable aid to the methods already described for the identification of mammal hairs under the microscope.

ELECTRICALLY HEATED STEAM BOILERS

THIS subject is ably discussed by Eric A. Lof in the *General Electric Review* for June, 1921, pp. 515-518.

The generation of steam by electric current opens up a new industrial field for utilization of electric power. Its universal use is, however, as yet impossible for economic reasons, but there are many special cases where its application will result not only in a direct economical saving but also in many advantages from an operating standpoint. One particular field where the electric boiler should prove very desirable is in connection with hydroelectric central stations where power can as a rule be obtained at a comparatively low rate and where combustible fuel is generally scarce. When circumstances are such that excess power is available at certain times, generally at night and on holidays, the economic advantages of an electric boiler plant are apparent; and the possibilities of storing up this surplus power or at least part of it as heat in so-called vapor-accumulators offers many new and interesting problems.

From the technical point of view the electric boiler problem in general does not offer any great difficulties, and a large number of such boilers are now in successful operation in all parts of the world. The stock losses of the ordinary boiler are eliminated, and by careful heat insulation the efficiency of the electric boiler may be as high as 96 to 98 per cent. The operating force can be reduced to a minimum, and even when the workmen are poorly qualified the automatic control devices will insure that the normal quantity of steam is continuously obtained under even pressure and without the risk of dry-boiling followed by the liability of explosion which here is quite non-existent. The steam pressure in the boilers can be raised very quickly, in certain cases within as short a time as ten minutes from the moment the current is switched on, a fact of great importance, especially for intermittent working.

The author then calculates the relative heating values of coal and electric heat and arrives at the ratio of $\frac{2.82}{8.5} = 3$. With coal at $5.00 per short ton, the equivalent cost of electric power would have to be not more than 0.085 or less than one-tenth of a cent per kilowatt-hour. This is, of course, only possible in localities where cheap hydroelectric power is available. On the other hand, the cost of fuel may be so high as to make the economical utilization of electric heating look more favorable. The foregoing figures refer of course only to the cost of fuel or power and they do not include the operating and maintenance charges which are very much reduced with the electric boiler. A 100-horsepower electric boiler would be rated 1,000 kw., a 150-horsepower 1,500 kw., etc.

Electric boilers may be classified in two distinct groups: First, such boilers in which the water is heated by means of resistances mounted within the boiler, and, second, such boilers in which the water itself comprises the resistance which is heated when the electric current is passed directly through it from electrodes immersed in it. The author then describes the construction and operation of each type of these boilers. The second type of boiler which is as yet comparatively new in this country, but which is quite universally used in Europe, has electrodes usually of iron, immersed directly into the water and the current is led to them through leads which pass through the boiler cover through steam-tight insulating bushings. The electrodes themselves are often surrounded by cylindrical insulating tubes, which assist the circulation of the water past the electrode. Several such boilers are in operation using electrode voltage of 10,000 volts, and it is said that twice this voltage may be used successfully for the larger sizes. Electrode boilers have been built in capacities up to 4,000 kw., and there would be no difficulty in building them twice this capacity.

A more detailed description of such an electrode boiler installation is given in *Elektrotechnische Zeitschrift* for January 27, 1921, pp. 78-79. It describes the new boiler room of the paper factory at Wargöns in Sweden. The installation consists of seven boilers each designed to take 2,000 kw., and to work at 150 pounds pressure. The electric supply is derived from an overland transmission line which is operated at 10,000 volts. The boilers are cylindrical upright vessels with domed covers through which the electrodes pass into the interior. Nineteen electrodes are arranged in the form of a hexagon within the boiler, and means are provided by which individual electrodes or groups of electrodes, can be cut out as required by the demands for steam.

ROSSI-FOREL SCALE OF EARTHQUAKE INTENSITIES

1. Microseismic shock: recorded by a single seismograph or by seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.

2. Extremely feeble shock: recorded by several seismographs of different kinds; felt by a small number of persons at rest.

3. Very feeble shock: felt by several persons at rest; strong enough for the direction or duration to be appreciable.

4. Feeble shock: felt by persons in motion; disturbances of movable objects, doors, windows; crealing of ceilings.

5. Shock of moderate intensity: felt generally by everyone; disturbance of furniture, beds, etc., ringing of swinging bells.

6. Fairly strong shock: general awakening of those asleep; general ringing of house bells; oscillation of chandeliers; stopping of pendulum clocks; visible agitation of trees and shrubs; some startled persons leave their dwellings.

7. Strong shock: overthrow of movable objects; fall of plaster; ringing of church bells; general panic, without damage to buildings.

8. Very strong shock: fall of chimneys, cracks in walls of buildings.

9. Extremely strong shock: partial or total destruction of some buildings.

10. Shock of extreme intensity: great disaster, buildings ruined, disturbance of the strata, fissures in the ground, rock-falls from mountains.

THE EVOLUTION OF CLIMATE IN NORTHWEST EUROPE

BY C. E. P. BROOKS, M.Sc.

THE paper dealt with the period from the maximum of the last (Würmian) glaciation to the present day; this period is divided according to the variations of climate into seven "phases" as follows:

Phase	Climate	Date
1. The Last Great Glaciation	Arctic climate	30,000-18,000 B.C.
2. The Retreat of the Glaciers	Severe continental climate	18,000-6000 B.C.
3. The Continental Phase	Continental climate	6000-4000 B.C.
4. The Maritime Phase.	Warm and moist	4000-3000 B.C.
5. The Later Forest Phase	Warm and dry	3000-1800 B.C.
6. The Peat Bog Phase	Cooler and moister	1800 B.C. 300 A.D.
7. The Recent Phase	Becoming drier	300 A.D. onward

These phases were of similar character over the greater part of northern Europe. The chronology is based on the recent work of Baron de Geer in Sweden, which agrees well with that of Penck and Bruckner for the Alps. The reconstruction of the climatology is based chiefly on botanical evidence as to temperature and rainfall, but archæological and purely geological data are also of importance. Each phase was illustrated by a map showing the probable meteorological condition and especially the storm tracks. The idea that geological changes sufficiently marked for recording have taken place in historical times will surprise many.

The last glaciation was a period of arctic climate in Europe with a border of extremely dry easterly winds and almost desert conditions. As the ice-sheet slowly decreased in size the temperature rose, until hot summers were experienced in Germany; but the climate remained dry. The Continental phase corresponds to the *Ancylus* Lake period with cold winters but hot dry summers; this is the first forest period of Scandinavia. The Maritime phase coincides with the subsidence causing the *Litorina* Sea, when the Baltic was more open to the Atlantic than at present; a warm, moist climate prevailed and extensive peat-bogs developed in Europe.

Elevation next caused a decrease in the size of the *Litorina* Sea, and an extension of the area of western Europe; at the same time climate became more continental, and the peat-bogs were replaced by extensive forests. Civilization attained a high level in Scandinavia and Ireland, while there is evidence of sea-borne traffic. This carries us to the beginning of the Bronze Age. The latter was a period of heavy rainfall over the whole North Temperate Zone, causing the weakening of the forests and great development of peat—the Peat-bog phase. About A.D. 300 this passed fairly abruptly into present conditions. The climate changes subsequent to 2000 B.C. are found to agree well with Pettersson's scheme of the variations of the "tide-generating force." Finally, the climatic variations in North America since the Ice Age were investigated, and it was shown that in the Atlantic and Great Lakes region the general sequence was similar to that of Northwest Europe, but the corresponding phases were not always synchronous, and the Later Forest phase was unrepresented. In northwestern North America, where glaciation was much less severe, there was simply a gradual passage to present conditions.—Abstract of a paper read at the Royal Meteorological Society, April 20, 1921.

OCCUPATIONAL DISEASES

DR. CHARLES BASKERVILLE has devoted a great deal of study to occupational diseases in the chemical industry and as Chairman of the Committee on Occupational Diseases for the American Chemical Society has made frequent reports of exceptional value. In the *Journal of the Society of Chemical Industry* Dr. Stephen Miall makes some comments on occupational diseases and his remarks which are discussed in an editorial in *Chemical and Metallurgical Engineering* are quoted with the editorial herewith:

"Broadly speaking," he says, "constant exposure to any chemical compound is likely to be injurious to health, particularly if it is likely to give rise to dust, fumes, or gas, and . . . an abundant supply of fresh air is the best method of protecting the health of the workers. . . . All forms of dust and fumes are bad. Constant exposure to coal dust and tar causes what is known as pitch-makers' cancer, tar being the main irritant in this case. The manufacture of marmalade causes injury to the skin by the peeling of oranges and lemons, fine silica dust affects the lungs in a particular way," etc.

Sometimes excellent measures of prevention do not cure, as was the case of prohibition by the Swiss Government in 1879 of the use of yellow phosphorus in making matches. The workers then felt that they could dispense with all precautions where the alleged "harmless" red phosphorus was used, and the poisonings became more frequent than before. It was necessary to alter the law.

Cases of poisoning by carbon monoxide, nitrous fumes and ammonia are increasing in Great Britain, and yet these cases are almost all due to ignorance of the dangerous character of the fumes on the part of the workers. There is no difficult chemical problem in preventing this form of poisoning. A fatal case of benzene poisoning was noted following "improvements" which decreased the ventilation, and an analysis of the air showed two to ten parts of benzene in 10,000 of air. No cases followed after the ventilation was increased.

Turpentine poisoning produces kidney disease and seems to predispose the worker to gout. Persons who are susceptible to the smell of a newly painted room have attributed the illness to white lead or to other causes. It is hardly believable that a volatile lead compound is given off as a gas or emanation from lead paint, and the experience of the past twenty years indicates turpentine as the delinquent.

Autopsies of fatal cases in New South Wales showed in analyses of livers from 0.1 to 0.9 grains of cadmium per pound with merely a trace of lead. Dr. Miall believed these occurred in the zinc-smelting industry of that region. The symptoms of cadmium poisoning include kidney disease, constipation and loss of appetite. Zinc is a general protoplasmic poisoning and in the higher animals it causes muscular contraction and kidney disease. Copper, tin, nickel and manganese have injurious properties, but cases of poisoning by them are rare.

"White lead has been a fruitful producer of disease. About thirty years ago there were many preventable cases of lead poisoning in Great Britain, amounting in the white lead industry itself to about 400 cases a year, in making china and earthenware 200 cases and in printing, glass, shipbuilding and other industries about 400 more, making over 1,000 in all. Restrictions as to improper use, removal of dust, substitution of an insoluble lead silicate for white lead in the glazes of china and earthenware, rules for wearing overalls, etc., have caused a steady decline. Indeed the number of cases has decreased from over 1,000 cases annually to eleven cases in 1898 and twenty-one in 1919. It is said that lead poisoning is not caused by particles of lead swallowed by the worker, but rather by even more minute particles floating in the air inhaled into the lungs and so getting into the system. The headache complained of by painters is more likely to be caused by turpentine than lead. Diagnosis is difficult, and poisoning by cadmium, turpentine, arsenite of copper and other agents is often erroneously classed as due to lead."

Nitrogen in the Arts and Industries

A Survey of the Part It Plays in Modern Economics, and the Sources of Supply

By George W. Phillips and J. Norman Taylor

THE need for combined nitrogen to supply the ever-increasing requirements of agriculture has been widely felt for many years past. In 1898 Sir William Crookes[1] in his famous address before the British Association for the Advancement of Science pointed out the necessity of increasing the wheat production by the application of fertilizers. He stated that unless the average world-yield of wheat—at that time 12.7 bushels to the acre—were increased through soil fertilization, there would be "just enough to supply the increase of population among bread-eaters till the year 1931. . . . If bread fails—not only us, but all the bread-eaters of the world—what are we to do? We are born wheat-eaters. Other races, vastly superior to us in numbers, but differing widely in material and intellectual progress, are eaters of Indian corn, rice, millet, and other grains; but none of these have the food value, the concentrated health-sustaining power of wheat, and it is on this account that the accumulated experience of civilized mankind has set wheat apart as the fit and proper food for the development of muscle and brain."

The consumption of nitrogenous substances for agricultural purposes rapidly increased until in 1905[2] nearly two million tons, not including cottonseed meal, were being used in the United States alone and estimates for 1919[3] show the consumption of fertilizers to be in the neighborhood of 7,500,000 tons. The demand for nitrogen in forms available for agricultural purposes is constantly growing and the problem of supplying the demand very fast becoming one of importance to the nation. As recently pointed out by Cameron[4] the intensive management of the soil for the cultivation of crop plants is still imperative upon this country, and an increased efficiency of yield may be brought about through the use of fertilizers.

The need of large amounts of nitric acid and of ammonia for the production of munitions necessary for the national defense, of explosives for use in mining and engineering operations, and for many other uses in the arts and the chemical industries is also an ever-increasing one which is growing by leaps and bounds.

Although the need for national independence in this regard was brought home to us with great force only through the advent of war, the importance of an adequate supply of nitrogen compounds was clearly recognized by Munroe[5] in 1909, at a time when the military demand was not generally apparent and had not been previously recognized. In concluding his address before the United States Naval Institute in that year and presupposing the erection in this country of nitrogen fixation plants, he said: "From this account of recent chemical progress it is evident that it is possible to conduct a prolonged war without robbing the soil on which the people depend for food of its fertility, and further, that, notwithstanding the enormous and constantly increasing demand for nitrogen compounds in agriculture and manufacture, this country has reached a potential degree of independence, as regards its supply of nitrogen compounds for military uses, such as it never before enjoyed, so that it needs hereafter to consider foreign sources of supply only from the economic standpoint. However, I desire to say regarding the plants for the fixation of nitrogen what I have repeatedly advised regarding plants for the manufacture of explosives, viz., that it is a wise policy for our Government to foster, and in a measure supervise, these manufacturing operations, and to look to it that plants for these purposes are so strategically located throughout the country as to be reasonably well protected from attack, so that they may serve the military establishment in case of foreign invasion from any quarter or of internal uprisings in any locality."

The importance of nitrogen in the national economy is evident for "history shows that every nation which has disappeared out of the civilization of the world went out by one or the other of two courses: It was either vanquished or destroyed by military processes, or it exhausted its soil and had to move."[6]

The nitrogen compounds needful for use in agriculture, for the manufacture of explosives and for use in the arts and the chemical industries are obtained from a variety of sources.

Certain plant orders,[7] [8] [9] [10] notably the leguminosæ, through the agency of bacterial growths which form nodules on the roots of such plants, have the power of taking nitrogen from the air and so fixing it that it becomes available for food for vegetation. The employment of the legumes and other nitrogen fixing plants in the rotation of crops,[11] therefore constitutes a valuable means of enriching the soil. Other plants obtain their nitrogen from such soil and then animals are nourished by the nitrogenous substances contained in these plants. Upon the decay of animal and vegetable matter, part of the combined nitrogen which they contain is, through the action of nitrifying bacteria, returned to the soil in the form of nitrates and of ammonia, but a large part of this nitrogen, however, is set free and returns to the atmosphere as nitrogen gas, and thus a cycle of nitrogen in nature is maintained on an enormous scale.

The nitrogen compounds obtained as by-products in the gas industry and from the by-product coke ovens are the result of nitrogen fixation effected ages ago by prehistoric plant life.

Another natural method of nitrogen fixation, which must take place on a very large scale, is that which is brought about through silent electric discharges constantly occurring in the atmosphere. The passage of the electricity through the air causes the nitrogen and oxygen atoms to unite with the consequent formation of nitric oxide. This in turn is oxidized to the higher oxides of nitrogen which are carried into the soil by rains and snows where they form salts by interaction with the naturally occurring basic substances.

The world's chief source of native nitrates, the Chile nitrate beds, although of somewhat doubtful origin,[12] and produced

[1] Report of the Sixty-eighth Meeting of the British Association for the Advancement of Science at Bristol in September, 1898.

[2] Munrot, Charles E., Chemicals and Allied Products, Bulletin 92, Census of Manufactures: 1905, Washington, Government Printing Office, 1908.

[3] Gaillard, Maj. D. P., Testimony before Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, Sixty-sixth Congress, 1920.

[4] Cameron, Frank K., The Outlook for the Fertilizer Industry. *Chem. and Met. Eng.*, Vol. 24, No. 1, p. 9. 1921.

[5] Munroe, Charles E., The Nitrogen Question from the Military Standpoint. Proceedings United States Naval Institute, Vol. 35, No. 3, 1909.

[6] Secretary Baker before the Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, Sixty-sixth Congress, 1920.

[7] Wiley, Principles and Practice of Agricultural Analysis.

[8] Merrill, George P., Rocks, Rock-Weathering and Soils: The MacMillan Company, New York, 1897, p. 203.

[9] Coulter, John M., Plant Structures: D. Appleton & Co., New York, 1904, p. 89.

[10] Kellerman, Karl F., Nitrogen Gathering Plants: Year Book, U. S. Department of Agriculture, Government Printing Office, Washington, 1910, pp. 213-218.

[11] Morse, W. J., Cowpeas Utilization: Farmers' Bulletin 1153, United States Department of Agriculture, Washington, 1920.

[12] Clarke, F. W., The Data of Geochemistry, Bulletin 695, Fourth Edition, Washington, Government Printing Office, 1920, p. 253.

probably to an extent by the process just described, is supposed to have been chiefly formed as a result of the accumulation of guano deposits which subsequently decomposed with the formation of sodium nitrate and other salts.[13]

The Chile deposits, together with the limited India deposits of potassium nitrate, constituted the main source of supply of combined nitrogen for all purposes until production by artificial means was stimulated through necessity.

Munroe[14] found that the consumption of nitrate of soda in this country alone increased about 40 per cent between 1900 and 1905. "During the World War the United States was absolutely dependent upon imported Chilean nitrate to supply over 75 per cent of its inorganic nitrogen demand, and imported during 1918 some 2,000,000 tons of nitrate, or two-thirds of the entire Chilean production."[15] The Chile deposits cover an area of over 400 square miles, a small portion being in Peru and Bolivia. The crude material, known as "caliche," is crushed and treated with boiling water, dissolving the crude nitrate. After settling, the liquor containing the nitrate is subjected to evaporation and crystals containing 95 per cent of sodium nitrate are so obtained. Comprehensive reports of the Chile saltpeter industry from the economic standpoint as well as the statistical, are given by Norton[16] and by Fisher.[17]

Utilization of the Chilean nitrates for the production of ammonium nitrate without the intervention of sulphuric acid was brought about during the war.[18] The process was devised by Freeth and Cocksedge[19] and is based on the metathetical reaction between sodium nitrate and ammonium sulfate. The reaction occurs in solution and is a reversible one, equilibrium in the distribution of the salts being reached in accordance with the law of mass action. A process first developed in France for the manufacture of ammonium chloride by the utilization through interaction of waste products from the Haber ammonia and the Solvay soda processes has recently been introduced in England and this country[20] as a new means of nitrogen fixation, but the Chile nitrate beds will long continue to be the source of a large part of the world's supply of *concentrated* nitric acid. This acid was known to the alchemists and was prepared by Geber in the ninth century by a process similar to that of the present time.

The successful commercial production of *dilute* nitric acid is accomplished by the arc process of atmospheric nitrogen fixation. Franklin[21] estimates that the amount of nitrogen in the atmosphere is equal to about 4041 x $(10)^{15}$ tons, assuming that the air over each acre of the surface of the earth contains 31,000 tons of nitrogen. It is however free. As Slosson[22] humorously says "That is the trouble: it is too free. It is fixed nitrogen that we want."

That the action of the electric spark in passing through air produces compounds of nitrogen was noted by Priestly in 1775. Later Cavendish, whose researches laid the foundation for much subsequent work in the gases, prepared potassium nitrate from the nitrogen compounds obtained in this way. Bertholet, in the course of his investigations of explosives, observed such fixation but apparently no attempt was made to develop Cavendish's discovery into a commercial operation until, as a result of the work of Bradley and Lovejoy, and following the granting of their patent in 1902, a plant was erected at Niagara Falls for the production of nitric acid by the arc process, but it failed of commercial success owing to economic conditions, as well as to the character of the arcs used, and this plant was abandoned.

In Norway, a few years later, Birkeland and Eyde established a plant also using the arc process and this plant proved commercially successful because the current could be obtained cheaply from the abundant water power at hand and because of the modification in the character of the arc used, this being a flaming arc drawn out by powerful magnets through which the air was forced in a tangential direction. The later invented Schoenherr and Pauling furnaces are still more efficient than the Birkeland-Eyde for through the spiral motion imparted to the flaming arc used, a greater amount of air is exposed to the heat of the arc. It appears, however, that before arc processes can compete with the other processes of atmospheric nitrogen fixation much investigational work remains to be done. "Even the most fundamental data on arcs, and particularly the transient arcs used in nitrification, are very little known and uncertain, and it appears that the possibilities of development are much greater with the arc process than with any other nitrification process."[23]

Other important methods[24] [25] of nitrogen fixation are the cyanamide process, the nitride and cyanide processes, and the ammonia process wherein elemental nitrogen and hydrogen are combined directly as in the Haber process. At the present time conditions are in favor of nitrogen fixation through the formation of ammonia. The ammoniates are the more desirable forms of nitrogenous compounds for use as fertilizers and should an emergency demand it ammonia can be oxidized to nitric acid. In his paper before the Washington Section of the American Chemical Society, May 8, 1919, Parsons[26] spoke of the development and application of Ostwald's process for doing this and gave a detailed account of the commercial oxidation of ammonia to nitric acid. Nitrogenous products of organic origin are a source of ammonia compounds and have been much used as a basis for the manufacture of fertilizer but most of these organic substances, such as tankage and dried blood from the packing houses, fish scraps, and cottonseed meal are now being diverted from use in manufactured fertilizers and used as stock feeds for which they command a higher price. Practically the whole supply of ammonia and its compounds was obtained, until recently, as a by-product of coke ovens, and, in a smaller degree, from other operations involving pyrolytic distillation, such as gas works, blast furnaces and boneblack factories. In 1905 there were produced in the United States from the by-product coke industry 15,773 tons[27] of ammonium sulfate, while the total amount of all ammonium compounds recovered from by-product coke plants amounted to only 30,317 tons,[28] necessitating, as demands increased, the importation of ammonium salts. The need for increasing the output of ammonia and its salts was shown in 1912 in the comprehensive report by Munroe[29] on the gas industry in the United States, in which it appears that between 1900 and 1909 the imports for consumption of ammonium

[13]Merrill, George P., Rocks, Rock-Weathering and Soils: The MacMillan Company, New York, 1897, p. 373.

[14]Munroe, Charles E., The Consumption of Nitrate of Soda in the United States: *Jour. Ind. and Eng. Chem.*, Vol. 1, No. 5, May, 1909.

[15]Burns, Col. J. H., Testimony before Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, Sixty-sixth Congrtss, 1920.

[16]Norton, T. H., Consular Report on Utilization of Atmospheric Nitrogen: Washington, 1912.

[17]Fisher, Herman Edward, Lieut. Commander, U. S. Navy, The Nitrogen Industry: *Jour. Franklin Inst.*, August, 1920, pp. 187-209.

[18]The United States Ammonium Nitrate Plant, Perryville, Md. (Atlas Powder Co.) *Chem. and Met. Eng.*, Vol. 20, No. 7, p. 320. 1919.

[19]U. S. Patent, 1,051,097 — 1913.

[20]A Significant Combination. Editorial in *Jour. Ind. and Eng. Chem.*, Vol. 12, No. 2, p. 107, 1920.

[21]Franklin, Milton W., The Fixation of Atmospheric Nitrogen: *The Chemical Engineer*, Vol. 14, No. 5, p. 453, 1911. From the *General Electric Review.*

[22]Slossen, Edwin E., Nitrogen: Preserver and Destroyer of Life: *The Independent*, Vol. 92, No. 3593, Oct. 13, 1917, p. 93.

[23]Steinmetz, Charles P., Theoretical Study of Nitrogen Fixation by the Electric Arc: *Chem. and Met. Eng.*, Vol. 22, No. 7, p. 300, 1920.

[24]See report on the nitrogen industry by Charles L. Parsons in the *Jour. Ind. and Eng. Chem.* for September, 1917, Vol. 9, No. 9.

[25]See address of Alfred H. White, Lt. Colonel, U. S. Army, The Present Status of Nitrogen Fixation: published in *Jour. Ind. and Eng. Chem.*, Vol. 11, No. 3, 1919, p. 231 et seq.

[26]Parsons, Charles L., Commercial Oxidation of Ammonia to Nitric Acid: *Jour. Ind. and Eng. Chem.*, Vol. 11, No. 6, pp. 541-552.

[27]Munroe, Charles E., Chemicals and Allied Products, Bulletin 92, Census of Manufactures: 1905, Government Printing Office, Washington, 1908.

[28]Munroe, Charles E., Coke Census of Manufactures: 1905, Washington, Government Printing Office, 1907.

[29]Munroe, Charles E., The Gas Industry in the United States, 1909: Press of *Progressive Age*, New York, 1912.

sulfate increased from 16,822,000 pounds to 79,453,025 pounds; for the carbonate from 298,778 pounds to 414,683 pounds; and of ammonium chloride from 5,065,057 pounds to 7,575,483 pounds. General Williams,[30] in testimony before the Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, said that, although the production of fixed nitrogen had been increased mainly through the construction of by-product coke ovens, we were in 1916 "still some 75 to 80 per cent dependent upon importation." It is to be noted[31] that Germany has declared her independence in the matter of nitrogen importation.

At the present time large quantities of ammonia are being produced by synthesis. As noted above, the synthetic methods consist either in the direct union of nitrogen with hydrogen to produce ammonia directly or in the production of cyanamid, nitrides, or cyanides to produce ammonia indirectly.

The direct synthesis of ammonia, whereby elemental nitrogen and hydrogen are caused to combine, was developed through the studies of Haber. In principle, nitrogen and hydrogen in a high state of purity, are caused to combine through the influence of a catalyzer and under pressure, the reaction occurring according to the following equation:

$$N_2 + 3H_2 \rightleftarrows 2NH_3$$

Although at first glance the operation appears to be a very cheap and simple one, the conditions obtaining cause the process to be both expensive and difficult. In the process now in use, the hydrogen is obtained through the decomposition of water by the action of carbon and requires a great expenditure of coal or coke as well as an enormous amount of energy. Also, owing to the great disinclination of nitrogen to enter into combination with hydrogen, our present knowledge requires the operation to be conducted at an exceedingly high temperature and under great pressure, and, as the reaction is a reversible one, the most favorable conditions produce only a 5 per cent yield. A more extended and successful application of this process is dependent upon its perfection by our investigators.

Ammonia is prepared from cyanamide by passing superheated steam over it, when the reaction, represented by the following equation, takes place:

$$CaCN_2 + 3\ H_2O \rightarrow CaCO_3 + 2\ NH_3$$

The cyanamide process for the fixation of atmospheric nitrogen was invented by Frank and Caro and today is the most important of the fixation processes. The product can easily be converted into ammonia, which in turn is readily oxidizable to nitric acid. Cyanamide is itself directly applicable as a fertilizer, as all of its nitrogen is available as plant food, and from it descends a whole family of useful nitrogen-containing products.

The first investigation of the cyanamide process in the United States was made by Munroe[32] in 1907 and in the same year "an experimental plant of commercial size was built in Canada at Niagara Falls where the cheapest available power was to be had."[33] Three years later (1910) the first product was delivered to the consumer.[34]

The industrial importance of the cyanamide process was early noted and emphasized by Munroe[35] who pointed out in 1907 that "in this" (the Frank and Caro process) "is found a practical and economical process for the fixation of atmospheric nitrogen, a further use for calcium carbide, and a valuable and very extensive field for the utilization of liquid air; while the product itself is a valuable fertilizer, which may be used directly as such. Furthermore, by very simple means a considerable number of useful chemicals may be produced from it, among which may be mentioned potassium and other cyanides, ammonia and ammonium sulfate or other ammoniacal salts, urea, guanidin, dicyanamide, and nitric acid."

In 1917, at the invitation of our Government, a plant for the fixation of nitrogen by this process was started at Muscle Shoals, Alabama. It was purposed to construct a plant of sufficient size to supply the nitrogen compounds necessary for the national defense and, in peace time, for agricultural purposes. A description of the Muscle Shoals plant by Fairlee[36] gives a detailed account of the methods used in this plant. Essentially, the cyanamide process consists in the union at a high temperature of nitrogen with calcium carbide in accordance with the equation

$$CaC_2 + N_2 \rightarrow CaCN_2 + C$$

The product is known as lime-nitrogen, or nitro-lim, and it contains about 60 per cent of cyanamide.

An important process for the production of ammonia and one which gives promise of greater application is the Serpek[37] process which involves the use of aluminum nitride. Beauxite and carbon are heated in an atmosphere of nitrogen at a temperature of about 1800° C., when nitrogen is absorbed as follows:

$$Al_2O_3 + 3C + N_2 \rightarrow 2\ AlN + 3\ CO$$

The aluminum nitride thus formed is decomposed by caustic soda with the formation of ammonia

$$AlN + 3NaOH \rightarrow NH_3 + Na_3AlO_3$$

Another process for the fixation of atmospheric nitrogen which has attracted considerable attention and which has recently been given industrial application is the Bucher[38] process for the production of cyanides. In this process, nitrogen is passed over a red hot mixture of sodium carbonate and coke contained in a twenty-foot tube and in contact with finely divided iron which acts as a catalytic agent, whereupon the reaction proceeds according to the equation

$$Na_2CO_3 + 4C + N_2 \rightarrow 2NaCN + 3CO$$

Ammonia may be prepared by further treatment of the cyanide and the resulting sodium carbonate again used in the process.

Recent researches on methods of activating nitrogen, excellently epitomized by Anderegg[39] in a paper in which he reviews the work done by Lewis, Strutt, Grubb and Wendt, and others, promise to be of great value in overcoming the many difficulties experienced in nitrogen fixation. This very inertness of nitrogen, its reluctance to enter into combination with other elements, is a property which makes it peculiarly adapted for use as a constituent of explosives because of its efforts to become free again. The almost instantaneous evolution of large quantities of gas and heat on explosion gives rise to a tremendous driving power. Nitroglycerine, for example, upon explosion, liberates 1300 volumes of gas from one volume of the substance, and the heat of the reaction expands it to over 10,000 volumes.

Black gunpowder, nitroglycerine, nitrocellulose, and trinitrotoluene are the most common of the manufactured explosives. These may be said to represent four general classes of explosives.

[30] Williams, Maj. Gen. Clarence, Testimony before Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, Sixty-sixth Congress, 1920.

[31] Caro, N. Prof., The German Nitrogen Syndicate: *Chem. and Met. Eng.*, Vol. 22, No. 15, p. 686. Translation from *Chemische Industric*, Nos. 13 and 14, July, 1919, by Arthur B. Lamb.

[32] Munroe, Charles E., Report on Calcium Cyanamid (lime nitrogen), New York, 1907.

[33] Testimony of Frank S. Washburn relative to the production of atmospheric nitrogen, before Senate Committee on Agriculture and Forestry: Sixty-sixth Congress, 1920.

[34] A description of the cyanamide process for nitrogen fixation was given by W. S. Landis in an address, "The Fixation of Atmospheric Nitrogen," published in the *Jour. Ind. and Eng. Chem.*, Vol. 7, No. 5, pp. 433-38, 1915.

[35] Munroe, Charles E., Chemicals and Allied Products, Bulletin 92, Census of Manufactures: 1905, Washington, Government Printing Office, 1908.

[36] Fairlee, Andrew M., Muscle Shoals Nitrate Plant: *Chem. Met. Eng.*, Vol. 20, No. 1, pp. 8- , 1920.

[37] A description of the Serpek process for nitrogen fixation is given by Samuel A. Tucker in the *Jour. Soc. Chem. Ind.*, Vol. 32, No. 24, pp 1143-4, 1913.

[38] Bucher, John E., The Fixation of Nitrogen: *Jour. Ind. and Eng. Chem.*, Vol. 9, No. 3, pp. 233-53, 1917.

[39] Anderegg, F. O., Activated Nitrogen: *School Science and Mathematics*, Vol. 20, No. 7, pp. 571-6, 1920.

Gunpowder was probably invented by the Chinese, but it was not until the thirteenth century that it was used in warfare. Since less than 50 per cent of the products of black gunpowder are gases, it is not comparatively a powerful explosive and has been superseded by more powerful ones. It is essentially a mixture of 75 per cent saltpeter, 10 per cent sulfur, and 15 per cent charcoal and is extensively used for sporting purposes and for mining and blasting. The variety of industrial and commercial uses to which explosives are put is described by Munroe[40 41] and by Munroe and Howell[42 43]. In a recent bulletin, Munroe[44] also calls attention to the outrages with explosives and the necessity for their control.

By the action of nitric acid on glycerine, in the presence of sulfuric acid which acts as a dehydrating agent, nitroglycerine is formed. It consists chiefly of glycerol nitrate. Modern methods of manufacture are but a development of Nobel's original process. It is a much more powerful explosive than black gunpowder and is very unstable. Nobel stabilized it by incorporating it with kieselguhr, giving it the name of dynamite, but most of our present day dynamites are mixtures of nitroglycerine with sodium nitrate and wood pulp and a small amount of calcium carbonate, which serves as the stabilizing agent by preventing acidity. It is employed in increasing quantities in mining, quarrying, the planting of trees, for digging ditches and foundations, in fighting conflagrations, in breaking ice jams, and in many engineering operations.

The development of explosives has been rapid. Knowledge regarding them advanced and other storehouses of energy were developed by the nitration processes. Nitrocellulose, an essential constituent of smokeless powder, is made by the action of nitric acid on cellulose, or purified cotton, in an analogous manner to that employed in the nitration of glycerine. It resembles cotton in appearance and when not confined burns rapidly but quietly when ignited. Through the use of a detonating primer, in the form of gun cotton, it releases its energy with enormous rapidity and violence. When nitrocellulose is to be used in smokeless powder its rate of energy release is lessened by forming it into a plastic mass with alcohol and ether and molding the mass, while plastic, into preferred shaped grains. Ballistite, another form of smokeless powder, is formed upon dissolving nitrocellulose in nitroglycerine. The U. S. Army has now abandoned the nitroglycerine-nitrocellulose powder and has adopted a straight nitrocellulose powder of definite nitrogen content, approaching more closely to the principle enunciated by Munroe that the ideal smokeless powder "should be composed of a single chemical substance in a state of chemical purity."

"The invention and introduction of safety powders has gone on rapidly abroad, and to a more moderate extent in this country, since the census of 1900 was taken. Since, through the researches in France, it was shown that ammonium nitrate diminished the temperature of the products of explosion and tended to render explosives containing it safe for use in fiery mines, the ammonia powders have had a marked increase in popularity. In the last edition of his book Guttman[45] gives two tabular lists of modern explosives for use in mines, one of "nitroglycerin safety explosives" and one of "ammonium nitrate and other explosives." In the first list there are enumerated 23 different explosives containing ammonium nitrate, of which grisoutine A contains as much as 90.45 per cent of this substance, while in the second list there are 38 different powders containing ammonium nitrate, one of these, ammonal, being composed of 95 per cent of ammonium nitrate and 5 per cent of powdered aluminum."[46]

"The Austrian artillery appears to have tentatively used the mixture of ammonium nitrate and aluminum known as ammonal, but the sensitiveness to percussion and friction of explosives having an aluminum base appears to have led to its discontinuance."[47]

Smokeless powders are variously named, depending upon their composition and the country in which they are produced. For instance, the chief English smokeless powder is known as cordite. The first smokeless powder adopted by the United States Navy for use in the large guns, which was invented by Munroe, was called indurite, the German powder is called ballistite, and the Italian product is known as solenite.

The principal "high explosives" manufactured in this country for military use are divided, according to Wright,[48] into (1) nitrated aromatic compounds and (2) nonaromatic explosives. In connection with the World War several new high explosives of the nitrated aromatic class were developed. Among them, trinitrotoluene, prepared by the nitration of toluene, was the most widely used. It is known under a number of names — T. N. T., tolite, trotyl, trinol and trilite. Picric acid, trinitrophenol, is also designated by a variety of names. In France it is known as "melinite," the British call it "lyddite," and the name given to it in Japan is "shimose."

Other nitro-aromatic compounds used as explosives are trinitroxylene, or T. N. X., trinitrocresol, and the nitrated anilines. A mixture of ammonium nitrate and T. N. T. was employed in the war to meet the enormous demands for bursting charges, and was known as amatol.

As in other branches of chemical industry, progress in the explosives industry during the past several years has been along the lines of improvements in processes of manufacture and of scientific control. New methods of nitration are being devised as well as studies made of the action of catalysts upon the reactions involved in manufacture. The lines of research on the stability of the finished products under various conditions have been broadened and it is interesting to note the observations of Custis,[49] who, working in this laboratory, found that light, especially ultra violet light, had a marked effect on trinitrotoluene, causing its decomposition to an extent that was easily shown not only by a change in color, but by a lowering of the melting point.

The many applications of the lower nitrated cellulose products, the pyroxylines, has given rise to the imitation ivory industry. Collodion, a solution of pyroxylin in ether and alcohol, has a restricted employment in surgery and is largely used in the manufacture of photographic films and plates, making possible modern photography with all of its remarkable applications. Due to their diminished inflammability, the cellulose acetates are taking the place of the nitrates in the manufacture of motion picture films. Collodions are used also for lacquers in the waterproofing of cloths and in the manufacture of artificial leather for use in making belts, bags, shoes, in book binding, in the manufacture of automobile upholstery, and of other artificial fabrics. Nitrated cellulose is the basis of one of the early French processes for the production of artificial silk.

[40]Munroe, Charles E., The Application of Explosives: *Popular Science Monthly*, Vol. 56, pp. 444-455, 1900.

[41]Munroe, Charles E., Explosives for Use in Industrial and Commercial Developments, a paper presented before the Second Pan-American Scientific Congress, Washington, U. S. A., December 27, 1915-January 8, 1916.

[42]Munroe, Charles E., and Howell, Spencer P., TNT as a Blasting Explosive: United States Department of Agriculture, Department Circular 94, Washington, Government Printing Office, May, 1920.

[43]Munroe, Charles E., and Howell, Spencer P., Picric Acid as a Blasting Agent: United States Department of the Interior, Bureau of Mines Serial No. 2243, Reports of Investigations, Washington, April, 1921.

[44]Munroe, Charles E., Regulation of Explosives in the United States: United States Department of the Interior, Bureau of Mines Bulletin 198, Washington, Government Printing Office, February, 1921.

[45]Oscar Guttman, Handbuch der sprengarbeit, Braunschweig, 1906.

[46]Munroe, Charles F., Chemicals and Allied Products, Bulletin 92, Census of Manufactures, 1905: Government Printing Office, Washington, 1907.

[47]Commandant A. R., Projectiles Containing Explosives. Translated from *Revue Generale des Sciences Pures et Appliques*, Vol. 27, pp. 213-221, by Charles E. Munroe, 1916.

[48]Wright, Carleton H., Lieut. Commander, U. S. Navy, American Production of Military High Explosives and Their Raw Materials: United States Naval Proceedings, Vol. 46, No. 10, pp. 1567-81, 1920.

[49]Custis, Horace H., Studies in Actinochemistry: *Jour. Frank. Inst.*, Vol. 184, No. 6, p. 877, 1917.

The incorporation of camphor with the lower nitrated cellulose gives rise to celluloid,[50] a substance widely used in the arts. The manufacture of celluloid and its fashioning into a great variety of articles constitutes an important industry.

The cyanides are used primarily in the extraction of precious metals from their ores. Their extremely poisonous character is emphasized by a recently published newspaper account,[51] attributing a number of deaths in a mining center in Mexico to the swallowing of water used in the chemical treatment of ores. Included in the cyanides are the ferro- and ferri-cyanides, Prussian blue, Paris blue, and Turnbull's blue, the cyanates, and the sulfocyanates (thiocyanates or sulfocyanides), all of which are largely used in the arts and industries.

Of the ammonia produced in the United States, approximately a fourth is used in refrigeration and for ice manufacture and about a third in the chemical industries for the manufacture of soda ash and various ammonium salts, while the remainder is consumed for miscellaneous purposes.

Many of the dyes are nitrogen-containing substances, and their manufacture involves the use of large quantities of nitric acid and other nitrogen compounds, while the manufacturing processes involved in their production and the potential value of the equipment of this industry in time of war makes them especially worthy of mention in this connection. The dyestuff industry is recognized as a growing and important one. The advantage of securely establishing an American dye industry, the necessity for researches in dyestuffs, and the relationship of the dyestuff plant to the explosives industry is detailed by Rose[52] in his recent brochure.

DETERMINATION OF ELECTRICAL EQUIPMENT FOR A MINE HOIST

By Graham Bright

THE rapid increase in reliability, the low cost of operation, the ready application of safety devices, and the growing availability of central-station power have made the question of installing a hoist of the electric type no longer debatable. Where adequate electric power is available, there are few cases where it would be advisable to install a steam or air hoist.

The type of electrical equipment depends largely on the nature of the power supply, its capacity, and the form of the contract under which power is purchased. In a large majority of cases, the available electric power is alternating current, three phase, 60 cycles. There is, however, considerable 25-cycle power in use; and in a few instances constant voltage direct current is the only power available for a small or an occasional medium-size hoist.

Where a new hoist is to be installed, the designer of the mechanical parts can readily take care of the maximum stresses likely to be imposed by the motor. Where the hoist is already installed and operated by steam or air and it is desired to substitute an electric motor for the engine, a careful check should be made to determine the advisability of using the old mechanical parts. In most cases it is better to install a complete new hoist than to attempt to use old mechanical parts. A steam engine has a definite maximum torque, which the hoist has been designed to withstand, while a motor may be able to deliver momentary torques beyond the strength of the mechanical parts of the hoist.

The selection of the proper type of electrical equipment can only be made after complete information is obtained and certain calculations made to determine the capacities required. There are several methods used in making hoist calculations, but no matter what method is utilized a fair degree of familiarity with hoists and hoisting conditions is necessary before an intelligent analysis and proper selection can be made.

Some of the hoist calculation methods are long and complicated. Where such calculations are seldom made, it is better to use the longer methods; but where the calculations are made daily, shortcuts can often be used to great advantage. Engineers associated with the writer, during the last few years, have felt that the various shortcut methods that had been worked up could be assembled in such a manner that any engineer working on hoisting problems could complete the necessary calculations in a short time and the results could be easily checked by another engineer. With this end in view, forms were evolved so that it was only necessary to fill in blank spaces to make a complete set of hoist calculations. These forms have been modified from time to time in accordance with suggestions by various engineers. At the top of the form is place for the name of the customer, filing information, the date, and the characteristics of the power system. Under the heading General Data are the specifications or the information necessary before calculations can be made. This is followed by the various steps necessary to obtain the complete hoisting cycle, which require only calculations of a fairly simple character. As many of the conditions of operation cannot be approximated more closely than 3 to 5 per cent, all calculations can be made by use of the slide rule.

In order to better illustrate the value of the method, examples are given showing the determination of the electrical equipment of an alternating current hoist, a direct current hoist with flywheel motor generator set, and a direct current hoist with a synchronous motor generator set. The forms are so arranged that a single sheet 8½ by 11 in. is required for the complete calculations of an alternating current hoist and but two sheets are required for either of the direct current hoists. In the typical case selected, the hoist is of the vertical type using self-dumping cages.—From paper to be presented at Wilkes-Barre Meeting, Am. Inst. Min. and Met. Eng.

THE ACTION OF SEA WATER ON TEXTILE FABRICS

CHARLES DORÉE in the *Color Trade Journal* for May discusses the action of sea water on cotton and other textile fabrics. Examinations were made of twelve samples as follows:

Cotton fabric;
Cotton fabric treated spermaceti;
Cotton fabric treated spermaceti and ironed;
Cotton fabric tanned with cutch;
Linen fabric;
Linen fabric treated spermaceti and ironed;
Linen fabric tanned with cutch;
Worsted fabric;
Worsted fabric tanned valex;
Silk fabric;
Silk fabric treated spermaceti;
Viscose silk.

The chemical changes produced in cellulose by the action of sea water and the influence of oxygen, light and bacteria are discussed. Without going into these details for which the reader would do better to refer to the original article, this interesting summary is given:

"1. Fabrics of cotton and silk are destroyed by immersion in sea water for three weeks, wool lasting somewhat longer;

"2. This destructive action has been shown in the case of cellulose to be due to micro-organisms and not to oxygen, light or the salts present;

"3. In its nature it resembles the 'mechanical' break-down of cotton sometimes observed under the 'beetling' process;

"4. If cotton is acetylated to the monoacetate stage so that is structural qualities are preserved, the resulting material is very resistant to sea water;

"5. Cellulose acetate silk now manufactured on a large scale has proved able to withstand the action of sea water for months."

[50] A review of the Celluloid Industry by F. Sproxton, in which the development of the industry and the manufacture and employment of the product are treated, is to be found in the *Jour. Soc. Chem. Ind.*, Vol. 39, No. 20, 1920.

[51] *The Washington Post*, January 20, 1921.

[52] Rose, Robert E., Molecules and Man: E. I. DuPont de Nemours & Co., Wilmington, 1920.

Making Various Objects from Gelatine*

Some of the Commercial Applications of This Interesting Substance

By P. Hoffmann

MANY articles of commercial importance can be made from gelatine or glue. Perhaps, the most familiar of these is the gelatine capsule used in medicine for doses of drugs with a very disagreeable taste. A great many other articles are made from gelatine, but the nature of the substance is often changed so greatly by the process of manufacture that the layman is deceived entirely, and cannot tell whether the article is made of gelatine or not. A few of the most important of these objects are tubes, piping, balls, artificial fruits, pearls or beads, so-called stones (gems), glass substitutes, etc.

In many cases the gelatine is used pure. Sometimes it is colored. Very often the gelatine is mixed with asbestos, glycerine, chalk, talc and other similar substances of the kind that are used in compounding rubber. Gelatine is soluble in water, and when the manufactured article must come in contact with water, the gelatine is made waterproof by treatment with formaldehyde.

Gelatine is bought generally in the form of sheets.[1] If the article can be made directly from the sheet, no other treatment is necessary. Otherwise, the gelatine is dissolved in water or else made plastic or fluid by the application of heat.

TUBES

Tubes of gelatine are made by dipping wires or rods of various diameters into the melted substance. A coating is formed on the mold and after the latter has been drawn out of the gelatine bath, the gelatine tube can be stripped off. This is, of course, possible only if the gelatine does not stick to the mold. To prevent this from happening, the wires or rods are smeared with a little grease, but when the gelatine tubes must be absolutely pure, it is necessary to put the tubes through a cleaning process to remove the grease.

Fig. 1 represents diagramatically the essential features of an apparatus invented by E. Weil, which eliminates this disadvantage. The parallel tubular molds are made of copper. These tubes are fastened into a header, 2, which is hollow and is provided with a water inlet tube, 3. The apparatus is submerged in the gelatine bath, 4, and a coating of gelatine

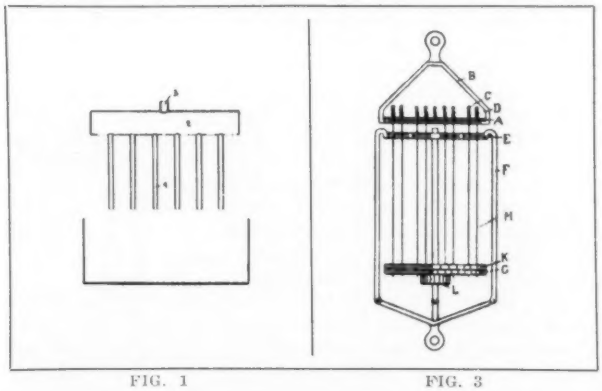


FIG. 1

FIG. 3

is formed on the tubes. The apparatus is then drawn out of the bath and moved to one side. Cold water is allowed to enter at 3 and flow out through the open ends of the tubes. A rapid cooling effect is obtained, which causes the tubes to contract. The gelatine coating is loosened and can be removed very readily.

*Translated from Kunstoffe, 6, 69-72; 80-81.

[1]Gelatine or glue comes in the trade either broken up in small pieces or ground to a powder of variable fineness. Bone gelatines are often sold in thick sheets or bars. Trans.

RUBBER FORMS

Another way of making gelatine tubes is to use rubber filaments or rubber tubing closed at one end so that it can be inflated with air. The filaments or threads are stretched on a frame and dipped into the gelatine. After this has congealed, the frame is pulled apart a little and the rubber forms are elongated. The gelatine coating is loosened and may be pulled off without any trouble. When the air-filled rubber tubing is used it is merely necessary to allow the air to escape, when the gelatine can be stripped off at once.

Gelatine tubing of special forms can be made with these rubber filaments. One end of the filament is fastened to the

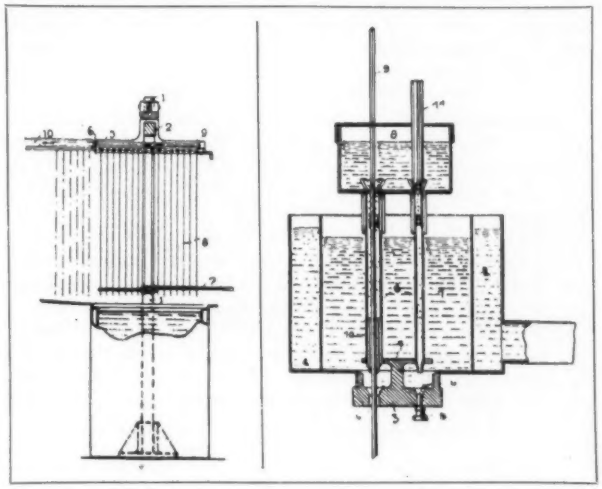


FIG 4 FIG. 5

dipping frame and the other is twisted as many times as desired and then fastened to the other end of the frame. The twisted tubing obtained in this way is used to a large extent for making beads and other articles of jewelry.

TUBES WITH OPEN ENDS

When a cylindrical form is dipped into gelatine, the end of the cylinder is covered with a film of gelatine and a tube with one closed end is obtained. To make tubes with both ends open, the dipping form has a raised portion.

In general a large number of tubes are made at one time. The wires are stretched on a frame or hang suspended from one. Fig. 3 shows an apparatus of the first type, devised by Jirotka. The wires M are fastened to springs D at their upper ends. The tension in the springs keeps the tops upright and tends to pull the wires to the top of the frame. The wires pass through a plate A and are fastened at the lower end between two plates K and G, which can be moved one over the other in opposite directions. A weight L provides the necessary tension in the wires. The plate A is attached to the hanger arrangement B. The finished tubes are stripped off the wires by loosening the tightened plates K and G and pulling down the plate E by means of the hooks F.

Fig. 4 shows a cross-section of an apparatus provided with loose hanging wires. (Bobe.) The post 1 is provided with a holder 2, which can be moved up and down by a suitable lifting arrangement. The holder has guides 3, into which the frame 9 with the wires 8 can be moved in and out. The fastener 6 secures the frame in the guides 3. By means of the movable rod 7, fastened to the post 1, the suspended wires are sub-

merged in the gelatine, contained in the vessel 5. After the wires have been pulled out of the gelatine bath, the catch 6 is loosened and the frame 9 is moved out of the guides 3 on a slide 10 and the gelatine coating allowed to dry.

MANUFACTURE OF LONG TUBES

In the apparatus described heretofore the length of the gelatine tube corresponds to the depth of the gelatine bath, and as the latter cannot be very deep the tubes are comparatively short. The contrivance shown in Fig. 5 is used to make comparatively long tubing. The gelatine bath is surrounded with a hot water jacket. At the bottom of the apparatus there is a mouthpiece, which is pierced with several holes. Each hole has a rod passing through it exactly in the center or when not in use is closed with a stopper. The gelatine runs out through the space between the rod and the sides of the hole and forms a continuous coating around the length of the tube, which extends beyond the opening 4. Every rod is surrounded by a tube 6 which is connected to an oil bath 8. The oil greases the rod so that the gelatine does not stick to it. The length of the rod determines the length of the gelatine tubing.

CONTINUOUS PRESSURE PROCESS

Continuous tubing can be made with the apparatus shown in Fig. 6. The operation of this contrivance requires the use of compressed air. A number of pressure cylinders 2 are set in a hot water bath. The cylinders are filled with liquid gelatine through a valve in the tight fitting cover. At the bottom there is an opening provided with a pin placed in its exact center. The size of this pin determines the thickness of the walls of the gelatine tubing. At the top of the cylinder there is an opening for the introduction of compressed air.

The air forces the gelatine out through the bottom opening. As the material emerges a current of cold air is played upon it and the gelatine tubing is made to congeal. The partly congealed tube falls on an inclined hollow plate 7 through

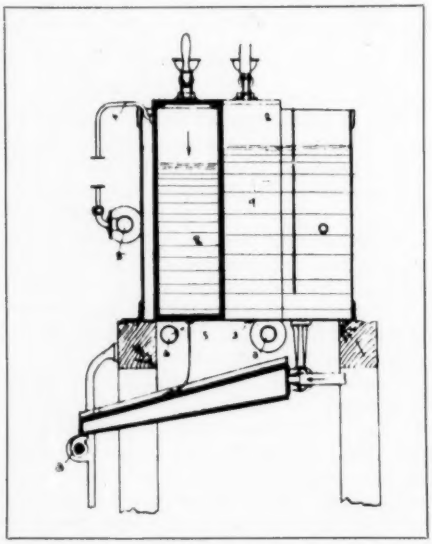


FIG. 6

which cold air is circulated so that the gelatine is cooled still further. The plate is given an oscillatory motion by means of the cam 8. A continuous tube of any desirable length is obtained in this way.

GELATINE CAPSULES

The dipping process is used to make capsules. Short pegs are fastened to a plate and the contrivance is dipped into a gelatine bath. The familiar capsules are formed in this manner. They are removed from the pegs and cut to the proper length. As one open end capsule must be placed within another, different sizes of each are required. These are obtained by making some pegs larger than others.

In another contrivance the pegs are arranged in a continuous band which runs over a pulley. The band dips into the gelatine bath and then runs along a sloping path. In this way capsules of very uniform wall thickness are obtained. After that the bands wind around a drum which rotates until the gelatine has congealed entirely. To cut off the capsule a

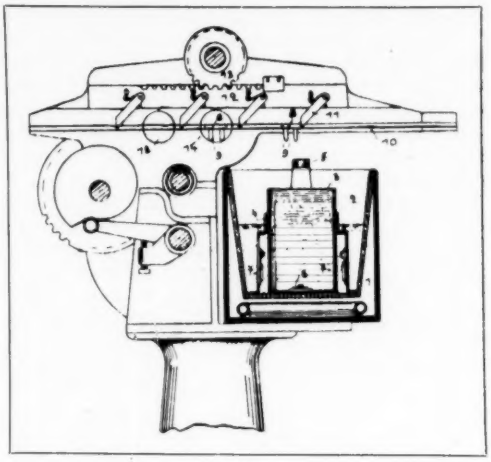


FIG. 7

band knife is used in which there are perforations with sharp edges. The capsules fit into these perforations and are cut off by the sharp edges. The band then travels along to another contrivance which strips off the waste gelatine remaining on the pegs; it then passes over brushes which coat the pegs with a little oil and finally is submerged in the gelatine bath again. The capsules fall into a part of the apparatus which pushes one-half capsule into another and the finished capsule drops into a collecting basket.

AUTOMATIC CAPSULE MACHINE

Capsules are made in large quantities in automatic capsule machines which are very ingenious in construction. Fig. 7 shows one of these machines, invented by B. W. Scott. There are two distinct parts to this machine; one, the gelatine container and lifting apparatus (the lower part of the figure); and two, the pegs and the contrivance for moving them across the gelatine bath. The first part consists of the usual water jacket in which there is placed a cylinder filled to the brim with melted gelatine. This cylinder 3 is set in a tight fitting housing 4. Both the cylinder and the housing are provided with valves at 6 and 7, both opening inward. A suitable contrivance raises the cylinder at the proper time, when the melted gelatine flows into the housing through 7, and when the cylinder is lowered again the gelatine runs into it through 6 and overflows. This prevents the formation of a skin of gelatine at the brim of the cylinder.

The second part of the apparatus consists of an endless band of pegs, traveling in guides from left to right (see Fig. 7). The motion of the band is controlled by a rack and pinion contrivance to which latches 11 are fastened which push the pegs along. The motion is intermittent, allowing time for dipping the peg in the gelatine cylinder 3 which is raised at the proper time to meet the peg which has stopped moving just above it. After the peg has been dipped, the cylinder is lowered and the peg travels along to the drying part of the apparatus. The entire action of the dipping machine is automatic.

Fig. 8 shows the arrangement of the complete apparatus. A is the dipping machine, B is the drying contrivance. The pegs pass through B and finally reach C from which they are fed to the assembling machine D. The feed is so arranged

that all the longer pegs are made to pass to the under part of D, and the shorter pegs to the upper part so that one-half of the capsule can be inserted into the other very simply. A suitable cutting tool cuts through the gelatine, which is then pulled off the pegs. The finished capsule is collected in baskets. The waste gelatine is removed from the pegs and after

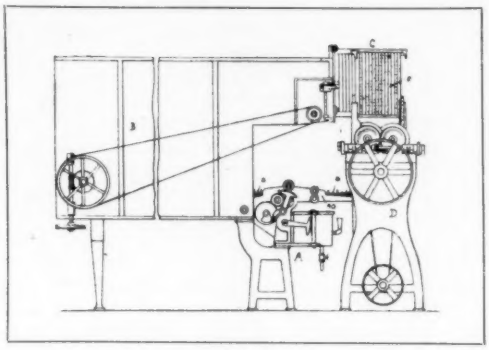


FIG. 8

the latter have been greased slightly they are pushed into the guides 10 and proceed to the dipping machine for a repetition of the operation.

The apparatus shown in Fig. 9 represents an entirely different method of manufacturing capsules. There are two gelatine baths, one at the top and the other at the bottom of the apparatus. These baths are connected by means of compound tubes, that is, two concentric tubes, provided with two stopcocks. While the top valve is open, the bottom valve is closed and the gelatine runs down in the space between the two tubes. A coating of gelatine is formed on them and the rest of the gelatine runs out when the bottom valve is opened, thereby closing the top valve automatically. After congealation takes place the gelatine tube is removed and put through a machine which cuts it up into proper lengths and closes the ends in one operation.

BALLS, ARTIFICIAL FRUITS AND OTHER LIKE HOLLOW OBJECTS

The dipping process is used to make these articles. As many of the latter must have small openings only, the dipping forms are made of rubber so that they can be inflated with air. The forms have an inner supporting frame, so that they do not collapse when immersed in the gelatine bath. They are placed in specially made holders, and provided with valves

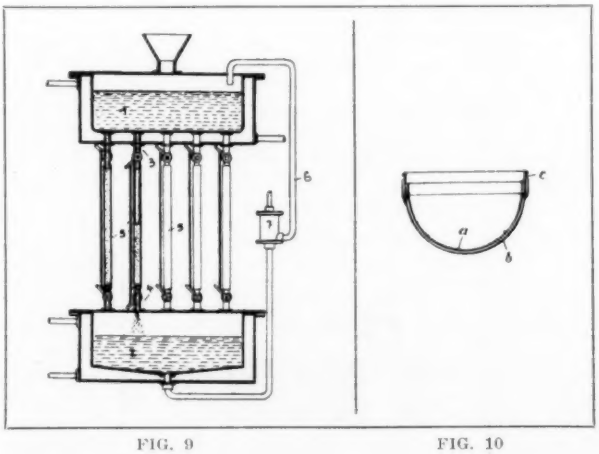


FIG. 9

FIG. 10

so that the air can be released and the forms deflated after congelation. The forms can then be drawn out of the gelatine product through the small opening left at the top where the neck of the rubber form extended.

Metal forms are used to make hemispheres and the like. To avoid greasing the form, an ingenious device is used, as shown in Fig. 10. This consists of a ring c which fits into the forms and is dipped into the gelatine bath along with it. The gelatine coating b does not stick to the mold and can be removed very easily by stripping off the ring c.

CLOSED HOLLOW SPHERES

Fig. 11 is a diagram of a machine used to make completely closed hollow spheres. There are two drums, whose axes are parallel to each other and over which an endless band winds. To this band the dipping forms are fastened in such a manner that they can be rotated. This is done by a cog wheel arrangement as the band passes around the helical shaped grooves in the drums. Under drum 1 at a distance equal to the pitch of the helical windings there is a container 5 in which there are some oil impregnated bulbs and a gelatine bath. The forms dip into the former first and then into the gelatine. They then continue on their way around the drum and finally reach drum 2 which is surrounded by a drying chamber where the gelatine congeals. The forms return again to the first drum. At this point the claws of a seizing contrivance grip the form and strip off the gelatine body and let it fall into a pair of clamps which are arranged at certain intervals on an endless chain 7. The clamps close so that the

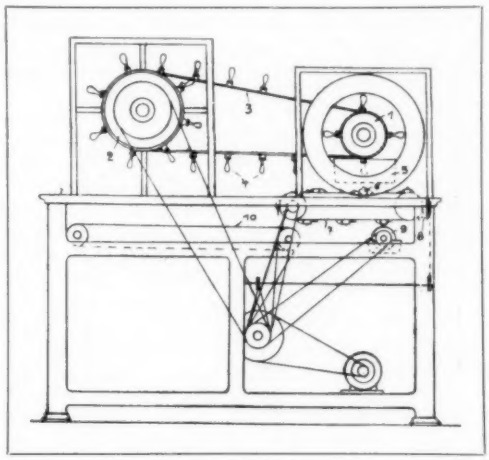


FIG. 11

neck of the globular gelatine body extends beyond them. The clamps then move along to a knife 8 which cuts off the neck of gelatine, so that a sphere is obtained with a hole in the top. This hole is closed up by dipping the sphere (still held in the clamps and moving along automatically) in a concentrated gelatine bath. The clamps open and allow the spheres to fall on a belt conveyor 10 which takes them to a moderately heated drying chamber. The heat causes the air within the spheres to expand and in this way the sphere attains a comparatively regular shape.

BEADS AND PEARLS

The shape of gelatine beads varies considerably. Sometimes the beads are more or less regular spheres or like bodies, which are pierced with holes for the most part. Then again they may be different lengths of cylindrical or many-sided tubes. For this reason the methods of manufacture are very varied.

Spherical beads are made by the aid of the apparatus illustrated in Fig. 12. The gelatine is squeezed out of the press 1 through a cylindrical tube provided with a center pin 3 and then passes between two rollers. These rollers rotating in the indicated direction (see figure) have hemispherical depressions in their circumference which form a string of spherical beads out of the tube of gelatine. The beads are connected by small pieces of tubing.

In another process the beads are made either by hand or by machines from gelatine which has been rendered plastic by

the addition of a small amount of water. The beads are then dipped for several seconds in hot water at 60 to 70 deg. Cent. and then cooled off by a current of air or by dipping in cold water. In this way they are made very smooth. To fasten together such beads, heated pieces of metal are stuck into them. Large beads are not made from pure gelatine. Very often the center is formed of cotton or glass wool wadding and a gelatine coating is congealed thereon. The finished beads can be given a mother-of-pearl gloss in the usual manner and then can be japanned or made insoluble by treatment with formalin.

THE STAMPING PROCESS FOR MAKING BEADS

Beads can be stamped out of the gelatine sheet. By this process, at first the string holes are stamped out and then the entire bead. The gelatine is rendered flexible by the addition of glycerine, so that the stamping can be accomplished without any trouble. In order to give the pearls the desirable gloss, they are coated with a varnish lacquer or with a solution of collodion. At the same time they are made very resistant to the action of moisture.

A very original process for manufacturing beads, gems and ornaments has been devised by H. Poussole. The different articles are first stamped out of the gelatine sheet in the rough. Then these rough forms are placed on a metallic screen and heated very carefully with a gas burner. After a short time, the gelatine begins to swell and as the heating is continued, the rough edges of the stamped form fuse

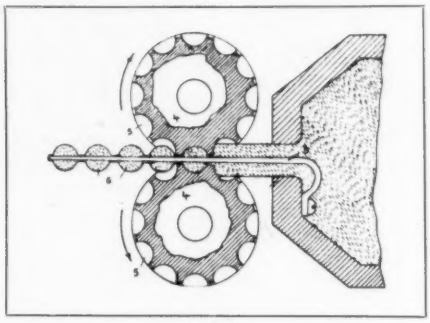


FIG. 12

together and become smooth, so that an object is obtained that is larger than the original but entirely smooth all around. When the object is cooled off, it shrinks, but still retains its shape, which corresponds exactly to the original rough stamped form.

Large quantities of beads are made from gelatine tubing, which is itself manufactured by any one of the processes described above. The tubes are cut into any desired lengths and then shaped into the bead. The interior of the tubing is filled with an easily workable doughy substance, such as flour dough, which is used for making noodles. This then becomes the center of the beads, effects a saving in gelatine and makes the beads more resistant to wear and tear.

FACETTED BEADS

Besides the type of bead described above the bead with a many-sided cross-section, the so-called facetted bead, is very popular. When the stamping process of manufacture is used, the facets of the bead are not very lustrous and must be made so by the application of a lacquer. This is merely a makeshift arrangement as the lacquer loses its gloss comparatively quickly.

A process has been invented by K. Wirth which avoids this disadvantage. Cylindrical beads are stamped out of gelatine sheets and are stuck on pins into which they fit very tightly. The outer surfaces of the beads are moistened slightly and they are placed in a bipartite die. The die is cut into the desired profile and possesses highly polished surfaces. After sufficient heating to make the beads plastic they are compressed in the dies for one to six minutes. They are then dried and strung. To prevent the beads from sticking together during the operation of pressing, the gelatine sheets, from which they are stamped, are made insoluble on the upper

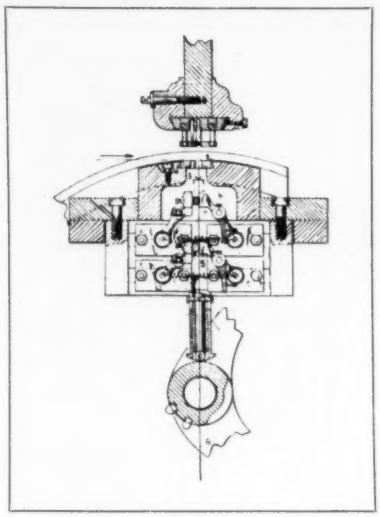


FIG. 13

and lower surfaces by painting with formaldehyde. When a composition gelatine is used, this procedure is unnecessary. In place of press molds, rollers made from metal glass or porcelain can be utilized to good advantage. These rollers are cut out into the desired outlines and the bead is pressed between two rollers after having been made plastic by heating.

Beads or pearls are made from gelatine tubes and worked up in various forms and profiles. The tubes can be placed in lathes and rotated about their longitudinal axes, whereby the facets and other similar profiles may be cut out of the gelatine, drawn out or burnt out by corrosion. The gelatine scraps are recovered and reused.

GELATINE TINSEL

Gelatine tinsel is much less expensive than the metallic tinsel. The round disks with small perforations are stamped out of gelatine slabs and are strung on threads. Two dies and matrices are used, the finished product being made in two steps. The matrix in the second step has a sharp pin which pierces the disks.

An automatic apparatus for cutting the hole in the disks and stringing them on a thread is shown in Fig. 13. The machine operates in a manner very similar to that of sewing by hand. The contrivance in the upper part of the figure holds the pins at the outset. The pins pierce the gelatine disks and are drawn through underneath by a pair of clamps and then returned to the clamps that held them in the first place. The

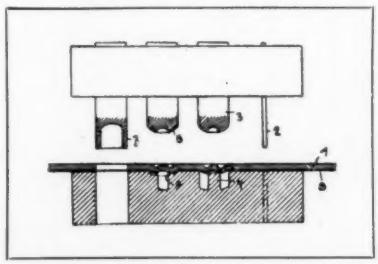


FIG. 14

perforated disks are finally pushed through the pin, attached to the cord 6 (see figure) and strung.

Another type of tinsel, which is used in large quantities, is made in the shape of a dish or bowl. Fig. 14 illustrates a ma-

chine used for making this kind of tinsel. The gelatine sheet is moved from one stamping die to another until it has been shaped to the desired form. The operation is very simple, merely moistening the gelatine to render it plastic and stamping with various dies as many times as necessary. Very many different shapes and sizes of tinsel can be made in this way. Buttons, stones (gems) and other like articles can be stamped out of thick sheets of gelatine by the same process.

GELATINE COMPOSITIONS

Most of the articles, made according to the various methods described above, are formed out of the pure gelatine, except for the small quantity of dyes added to give a distinctive color to the product. This is particularly true of gelatine tubes. However, considerable quantities of this commodity and others of similar nature have been manufactured from gelatine compositions. An example of such a composition (Traube and Michaelis) is as follows: 150 grams glue, 40 to 100 ccm. of glycerine and about 100 grams powdered talc. Sheets or slabs are cast from this mixture and rendered sticky on one side by heating and then wound around a metallic drum. When the longitudinal seam is sealed by melting the gelatine around it, the hardening of the finished pipe is accomplished in the usual way by the use of formaldehyde. This process is very similar to that of manufacturing rubber tubing

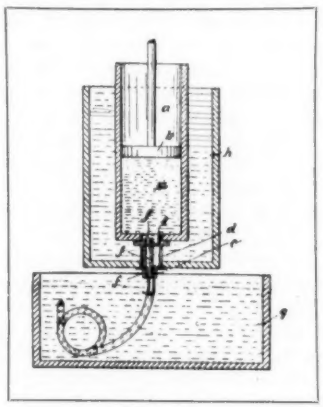


FIG. 15

and piping. Just as in that process, different fabrics can be inserted between the layers of gelatine composition or else the mixture can be cast around the sheet of fabric.

Another gelatine composition, consisting of talc, asbestos, chalk and other like substances, is worked up in an incorporating rolling mill just as is used to compound rubber. The mass is then drawn out on a calender to form sheets and covered with a layer of fabric. Several layers may be built up in that way and then the product is wound around a drum to form a tube or pipe. This is wrapped in moistened paper and heated for a certain length of time. The paper tends to contract as its moisture is evaporated, so that a certain pressure is exerted on the tubing, which results in a more compact adhesion of the several layers that go to make up the pipe.

Instead of making the piping by winding sheets around drums, a press is used as illustrated in Fig. 15. The cylinder *a* contains the gelatine and is surrounded by a hot-water jacket *h*, so that the gelatine can always be kept at a temperature of 450 deg. Cent. The gelatine is squeezed through a die, fastened to the lower end of cylinder *a* by pressure exerted through the piston *b*. The die is made in such a way that a tube is formed with a hollow center. This is done by making the pin, which is inserted in the opening in the die, hollow. Directly underneath the die there is a container filled with alcohol or any other suitable liquid which can be kept at about 15 deg. Cent. The continuous tubing, squeezed through the die, falls into this cooling bath and is congealed immediately. Its hollow interior permits the penetration of the congealing fluid and makes the action just that much more effective and rapid.

Many other objects can be obtained from gelatine compositions by squeezing them through dies and quickly cooling the product as it is formed. Hollow articles are made in parts and then joined together by melting. To harden the inner surface of such objects, as for example in making balls by combining two hemispheres, a small piece of absorbent cotton, moistened with a little formalin, is fastened on the inside of the hemisphere at a point where the gelatine wall has been thickened. After the exterior of the ball has been hardened, the ball is inflated by means of a sprayer which pierces the thickened wall of the ball. Afterward, the hole is closed up with a gelatine plug. The hardening solution consists of a 3 to 5 per cent solution of formalin to which a little glycerine is added, in a proportion corresponding to the glycerine content of the gelatine composition.

THE MACKENZIE OIL FIELD

By T. O. Bosworth

THE two main alternative routes from Edmonton to Fort Norman are the Athabasca River route of 1370 miles and the Peace River route of 1695 miles. The two routes coincide for the final 868 miles, which includes the steamer route across the north end of Great Slave Lake and down the Mackenzie River. On both the Athabasca and the Peace the ice goes at the end of April; on the Mackenzie it breaks up in the latter part of May; but the ice on Great Slave Lake delays transportation, as it generally remains until the middle of June. The Mackenzie River remains open for navigation for about four and a half months.

At low water, the channels of these rivers are not to be depended on for boats of more than six feet draft. The current ranges from four to two miles an hour, going from south to north. The lakes are subject to bad storms, and it is sometimes rough on the Mackenzie River, which is from one to three miles wide.

The winter temperatures in the north do not go much lower than in the worst part of winter at Edmonton or Winnipeg—but they continue much longer. "Forty below" weather may last for six weeks or more.

Until the oil field is further proved and developed, the oil will be brought southward along the waterway, to the railroads of Alberta, by the route described. Motor barges of several hundred tons' capacity can be employed. Two fleets of these will be required, one operating north of the Smith portage, and the other south of it. The journey for the oil consists of three parts:

1. *Oilfield to Fort Smith.*—From the wells, the oil will be conveyed up the Mackenzie River, across the end of Great Slave Lake, and then up the Slave River as far as Fort Smith. This voyage of about 800 miles will be performed by the first fleet of barges.

2. *Fort Smith to Fort Fitzgerald.*—At Fort Smith, where navigation is interrupted by the Smith Rapids, the oil will be pumped across the rapids, through an 18-mile pipeline, into the second fleet of barges at Fort Fitzgerald.

3. *Fort Fitzgerald to Fort McMurray.*—From Fort Fitzgerald the oil will be conveyed along the upper portion of the Slave River, across the end of Lake Athabasca and up the Athabasca River as far as Fort McMurray, where tank cars on the railroad will receive it.

Further railroad construction, and improvement of the waterways, also, are certain to be undertaken if the developments in the oil field justify them. Possibly the oil will be partly refined in the north, to reduce the cost of transportation. If present hopes and expectations are realized, the oil will doubtless eventually go by pipeline to one of the inlets on the Pacific coast. The shortest distance to tidewater is 550 miles.

The strata exposed in the Mackenzie oil-field district include:

Tertiary—Shales, sandstones, and lignite.

Cretaceous—Clay-shales and sandstone.
Devonian—Limestones, shales, and sandstones.
Silurian—Limestones, etc.

It is in the Devonian only that the oil and gas have been found.

OCCURRENCE OF THE PETROLEUM

The remarkable character of the Fort Creek shales and Beavertail limestone, rather than the oil seepages, led to a favorable view of the prospects of this field. These rocks are black with bituminous material, which appears to be present as a fixed constituent. In some places, where these beds are much exposed, the bituminous odor is so strong that it may be noticed at a distance of half a mile. Fluid oil is not visible in these bituminous rocks, though where they pass under water some liberation of gas is seen. But oil might reasonably be expected in the porous beds of the overlying thick series of clay-shales and sandstones, and also there was a good chance that at depth, and under favorable structure, accumulations of petroleum might occur within the black shales and limestones themselves.

An examination of the overlying Camp Creek series in several localities showed either oil seepages or the presence of oil when the rock was crushed under water. The principal seepages were seen on the shores of the Long Reach, where the river flows for 75 miles along the outcrop of the Camp Creek series.

Extending over many thousands of square miles there is 1000 feet or more of richly bituminous beds, and overlying these rocks is 2000 feet of shales and sandstones, from which seepages of oil arise. This mass of petroliferous deposits is traversed by large anticlinal folds.

The high parts of the anticlinal hills are not now favorable territory, for there the oil-bearing beds have been denuded away, but on the flanks of the folds, and on certain low parts of the crests, and on the minor structures, the petroliferous beds are more or less intact.

The oil has a paraffin base and is of high quality. The seepage oil, obtained on digging in the outcrop of the Camp Creek beds, has a greenish-black color, and a strong paraffin smell. The specific gravity is 0.905. The crude oil from the well is of light color, low specific gravity, high gasoline content, and low cold test. From an analysis made at Alberta University, in commercial terms the oil consists of gasoline 22.5 per cent, illuminating oil 38.5 per cent, light lubricants 33.9 per cent, and medium lubricants 4.1 per cent, with a refining loss of 1 per cent.

The petroleum within the region here discussed appears to have been first recorded about a century ago by Sir John Franklin, who saw, near Bear Mountain, "sulfurous springs and streams of mineral pitch."

Also, for the past fifty years or more, a "tar spring" far inland from the river has been known to the Hudson Bay Co.'s men at Fort Good Hope, who have utilized its seepage oil for tarring their canoes.

In 1887, an exploration of the Mackenzie Basin was made by R. G. McConnell, who reported the occurrence of bituminous or petroliferous rocks throughout the valley.

It was not until 1919 that a drilling outfit was conveyed into the Northwest Territory, by the Imperial Oil Co. The location of this first test well was chosen in 1914, as a site where a hole of moderate depth could not fail to penetrate the several petroliferous formations which had been found.

The well is on the river bank about half-way down the Long Reach, near the mouth of Camp Creek, where there are copious seepages of oil. Geologically speaking, the location is upon the outcrop of the lower measures of the Camp Creek Series, low down on the southwest flank of the Wolverine anticline, about 8 miles from the axis of the fold.

It was clear that the oil rocks would lie rather shallow here, but by not going farther "down the dip" there was less risk of finding the beds occupied by water and less chance of failure to reach the desired horizons because of engineering difficulties in such a remote country.

The well was drilled during the summer of 1920. Almost from the start oil came into the hole, and before a depth of 100 feet was reached a yield of five or ten barrels a day could be obtained.

After passing from the Camp Creek series into the dark Fort Creek shales, the oil showings still continued, until, at a depth of 783 feet, a strong flow of oil was encountered which spouted to a height of 70 feet. After about ten minutes the well was capped. Some hundreds of barrels of oil issued from the well before it was finally shut in, but no dependable estimate of its capacity can yet be made. It is thought that the initial output will be at least 500 barrels a day.

Whether or not this first well will be a steady, large producer remains to be seen, and, in any case, many more wells must be drilled before the importance of the field is fully proved.—Extracts from Paper Read at Meeting of Royal Society of Arts, April 27, 1921.

DEVELOPMENT OF THE HUMAN FOOT

IN new-born infants the soles of the feet are turned opposite each other exactly as they are in climbing animals and the great toe likewise undergoes conditions of development which indicate that it was derived from the "thumb" of a climbing foot. Even at the present time there are races of men which are distinguished by the great flexibility of the foot. A German observer, named E. Bälz, remarks, that the thumb-like use of the great toe is very remarkable among the Japanese. This toe can be moved independently of the others and can be pressed so firmly against the second toe that quite small objects can be picked up by it. A sewing woman often picks up the goods she is working with between her toes and "handles" it in this manner with great ease. Another observer describes similar use of the toes among manual laborers—or should we say pedal laborers—in some parts of India. The Australian blacks, whose feet are marked by the shortness of the great toe and the comparative length of the other toes, are capable of holding a wooden stick from which they are making a spear with the foot, clasping it quite as firmly as one of us could do with his hand. This remarkable grip possessed by their toes is also very useful to them in tree climbing.

It is not certainly known how this power of opposition of the great toe to the other toes, and the great flexibility of the foot has been lost. A recent writer, however, Herman Klaatsch, in his work *Werdegang der Menschheit usw.* (The Development of Humanity, etc.), expresses the opinion that this loss is due to a peculiar sort of tree-climbing which is still common among savage peoples. The Australians, for example, climb smooth tree trunks without making notches in them. A flexible twig is bent around the stem and held by the climber with both hands and pushed steadily higher up the trunk as the man ascends. It is quite possible that this sort of climbing machine may have been very extensively used among the ancestors of man. It must be remembered that the tops of trees were a very happy hunting ground for them, so to speak, with respect to birds and their nest, as well as other small animals, besides which they served as a refuge in times of danger and possibly, too, as shelters by night. Individuals who happened to have feet varying in the direction of the present human foot, from the norm of the climbing foot, would possess an advantage in such cases, while in ordinary individuals the divergent great toe would act as a hindrance.

It is worth noting, too, that the marked development of certain groups of muscles in human beings, which are quite insignificant—namely, the masses of muscles found upon the shoulder and upon the buttocks, are precisely those which are especially serviceable in *human* mode of climbing, for the thrusting upwards or the pushing downwards respectively of the trunk. Moreover, it is these same muscles which are best suited for the molding of the spine in an upright position, as well as for that refraction of the shoulders by means of which a free movement of the head is secured.

Why Flowers Fade*

The Processes of Withering, As Reduced to Botanical Terms

By Hans Fitting, University of Bonn

An address presented before the Natural History Society of Rhenish and Westphalian Prussia, on the occasion of their 75th principal assembly, Oct. 9, 1920.

I. THE PROCESSES INVOLVED IN WITHERING

In the case of most living organisms the death of the individual or some of its parts is as characteristic as its development . . . and deserves as careful an investigation. . . . Such a group of processes with respect to the blossoms of plants forms the subject of the following paper. And we select this subject, not only because of the general interest which the fading of flowers and the phenomena of the post-florescence possesses for flower lovers and for gardeners, as well as for florists and for plant physiologists, but also because the investigations which have been conducted along this line during the last ten years, have given us a far more profound understanding of these processes themselves and have likewise thrown important light apparently upon the general physiology of plant development.

Even a superficial observation of flowers reveals that their withering is not of a single type, but that as is the case in so many phenomena of organic life different ways and means are involved, even in those nearly related to each other. The various portions of the flower, the calyx, the corolla, the stamens, and the ovary, are merely modified forms of the leaves and share the properties of these, including the process of withering. The leaves of plants wither in different ways. In the case of herbs the leaf and stem die down together through a process of drying or rotting, but in the case of most trees and shrubs the leaves are discarded while still living through an active vital process. . . . This consists in the formation of a transverse layer of cells formed at the base of the leaf stem in such a way as to neatly cut the leaf off. . . . A process of "autotomy" such as is accomplished by means of a different mechanism in the animal kingdom. Only in exceptional cases, as in the oak and the beech, are the leaves not discarded while still living but remain in a dried condition clinging to the tree until the buds begin to unfold in the following spring. This thrusting off of the leaves is generally preceded by a very striking change of color, except in some cases such as that of the alder. This is due partly to the decomposition of the grains of chlorophyll and partly to a formation of certain pigments especially yellow pigments, which consist partly of carotin and xanthophyll, which are insoluble in water, partly in chemical combinations not yet understood, which are soluble in water; very frequently also red anthocyanins to which the red color of leaves is due. These changes of color are in their turn due to a diminution in the protoplasm of the leaf cells and connected with this is an emigration of valuable leaf materials into the stem, especially of nitrogenous albuminoids, and phosphorus-proteids as well as a portion of the potassium, while other substances such as the materials of the cell wall together with calcium, magnesia, and other material constituents remain behind.

The methods by which plants get rid of those parts of their blossoms which have already fulfilled their function, are very similar on the whole but vary from each other in certain particulars.

THE DROPPING OF PETALS

1. Portions of the flowers are divided off by a transverse layer of cells of different character as described in the case of ordinary foliage. However, while these separation seams as we may call them consist of very small round cells rich in plasma, they are not (as is usually the case in the foliage), formed shortly before this self-amputation, but exist from the beginning. The process of amputation itself may require only a few minutes or even seconds, and while the portions of the flower which are discarded appear to be perfectly fresh and unchanged. This is true in the case of the flower petals of poppies, many of the rose family (including not only roses themselves but peaches, apples, plums, almonds, apricots, pears, and quinces), varieties of geranium, erodium, and pelargonium, as well as in many of the ranunculæ, the magnolias, the flaxes, the myrtles, of the umbellate plants, of the azaleas, the scrophularias, the veronica, the digitalis, the borage, the fuchsia, etc., etc.

In other cases the discarded portions wither before their amputation, a process which begins more or less near the point and which is accompanied by a greater or less change of color, as in the tulips, the lilies, the fritillaria, the iris *ensata*, most of the cruciferæ, the snapdragon, and many of the Laliatæ, the pumpkin, the evening flowers, etc.

2. In some other plants the parts of the flowers with which the plant is done are not amputated while still living but undergo a change of color and then remain withered and dry, clinging to the fruit for a longer or shorter space of time; in such cases it is probably true that in some plants these portions of the plants assume new functions, such for instance as facilitating the distribution of the ripened fruit. Blossoms of this type include the lily-of-the-valley, the narcissus, the orchids, most of the irises, the clovers, the erica, many of the pinks, the tobacco, the petunias, the asters, and probably the violet and pansy. . . .

Many differences of detail appear in the withering process according to the part of the blossom discarded, the order observed, etc. Frequently the entire blossom is cast away, sometimes while quite alive and fresh as is the case with the male blossoms of many plants; sometimes the blossom withers before being dropped as in the case of the male flowers of the gourd and pumpkin family; sometimes the upper portion of the blossom separates while quite fresh from the ovary beneath it, as in the fuchsia; sometimes this part is entirely withered as in the primroses, etc., sometimes the calyx drops off before the petals as in the case of the poppy, and sometimes at the same time as in the ranunculæ, the cruciferæ, the touch-me-not. In other cases still the plant amputates only the petals while the parts of the calyx remain clinging to the fruit either dry or withered, sometimes the stamens also remain in a withered condition as in strawberries, pears, roses, flax, etc.; or it may be that the calyx is retained while the stamens are amputated either before, after, or at the same time as the petals. Sometimes, too, the style is dropped while still living after fertilization has taken place, while sometimes, on the other hand, it clings to the ovary in a dried condition.

In all those cases where the portions of the blossom discarded are still living, the alterations which occur in them are of peculiar interest. . . . There are certain definite cases of partial death. . . . These processes of senescence and death consist first in the above-mentioned change of color—*i.e.*, in a yellowing or fading or in an actual change of color, *e.g.*, very frequently from blue or violet to red which indicates the appearance of acids in the cell sack and sometimes, on the contrary, in the change of red to blue or violet tones which indicate a removal of acids from the cell sack. In the aging blossoms of the pulmonaria, for example, this change of color from the red of youth to the blue of age is very striking. It is a definite sign of irreversible chemical processes.

(In some flowers a similar change of color is not due to age.

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but to an external factor like heat, as in varieties of the erodium; even a few degrees rise in temperature changes the color of these blue blossoms, first to a wine red and then to a clear rose color, and this is true both of the dead and the living petals. When the flower is cooled off again the blue color gradually returns.) The next step in the progress toward death consists in a gradual withering and crumpling, often accompanied by the passage of the cell sap from out of the cell into the intercellular spaces. . . . This exudation of the sap indicates that the impenetrability of the cell plasma has diminished or ceased as is customary sooner or later in the death of living cells. . . . Possibly, too, the withering and crumpling referred to are directly due to this exudation of the cell sap.

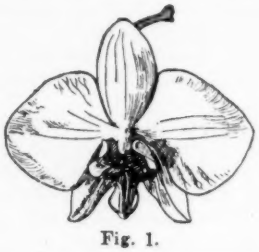


Fig. 1.

Fig. 2.

1: Front view of Phalaenopsis, the day after opening. 2: Same flower viewed from the side before pollination

It must not be supposed, however, that the increasing growth of the fruit causes the death of other parts of the blossom through a suction of the cell sap as might be thought; for, as a matter of fact, the morbid processes follow the same course in unfertilized as well as in fertilized flowers. However, it seems to me not improbable that, at least in those cases when the senescent portions remain clinging to the plant for a considerable time, material may emigrate from them before they are actually dead. This is indicated, at any rate, by my personal observation that in the case of the tropic orchid *Rhynchostylis retusa* the plasma is impoverished both before and during the process of withering.

The Closing of the Flower.—In the case of many flowers the process of fading is complicated by the fact that the blossoms first close to a greater or less degree before they actually

Fig. 3.

Fig. 4.

Fig. 5.

Further phases of Phalaenopsis. 3: Front, after it has begun to close. 4: Side, 24 hours after pollination. 5: Side, 48 hours after pollination

wither. This is the case in the irises, in many though not all orchids (Figs. 1-5, 6-9) the mallows, most of the cruciferæ, the primrose, many cactuses, etc. These closing or rolling up movements are definite life processes, which, under certain conditions, take place in a very brief space of time, only a few hours. In many cases they are based upon the fact . . . that the growth upon the convex side is more rapid than that of the concave side. In other cases it appears, according to measurements made by me of the tropical orchid *Phalaenopsis amabilis* (Figs. 1-5) the closing movement is effected by a shortening of the concave side. This may be followed by an excision of the part of the blossom concerned or by its withering or by both.

Even more remarkable are further complications in the fading process which depend upon whether the blossom was fertilized or unfertilized. In the latter case, the fate of the separate parts of the blossom may be very different; *e.g.*, this is peculiarly striking in certain tropical orchids, such as the *Phalaenopsis violacea* which has marvelously beautiful blossoms of a mingled white and violet: if the latter are not fertilized they close themselves (Figs. 6-8), grow yellow, wither and fall after a few days. If, however, they are fertilized, they likewise close themselves and begin to grow yellow and wither; but after this they gradually acquire an intensely green color, become once more firm in contour, begin to grow and retain a living and green condition until the fruit is ripe (Fig. 9). . . . Similar differences are found in the style of many tropical orchids; if not fertilized they become yellow and withered, but when fertilized while they begin by turning yellow, they immediately, thereafter, or at the same time, swell greatly (Figs. 10-11) and remain clinging for a long time to the ripening ovary. . . . Still other alterations including those of an anatomical nature, may be experienced by the corolla or the calyx as a result exclusively of fertilization, which we cannot here pursue, however, in spite of their importance with respect to physiological developments.

II. THE CONDITIONS THAT CONTROL THE PROCESS OF WITHERING

Let us now inquire into the causes of these changes. We observe, to begin with, that every variety has an absolute dura-

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

PHALAENOPSIS VIOLACEA

6: Front, day after blossoming. 7: Side, day before pollination. 8: Side, three days after pollination. 9: The ripening fruit, with a perianth entirely green

tion of the blossom which is peculiar to itself, just as the duration of the foliage is specific in nature; while in our latitude the latter has among deciduous plants only *one* period of vegetation, lasting therefore only a few months. This period may continue for several years among the so-called evergreen plants. In the same way the persistence of flowers is very various. Some kinds of plants, to the sorrow of flower lovers, retain their magnificent blossom for only a few hours; there are others which retain their beauty for several days; while there are yet others finally, *e.g.*, the tropical orchids which remain fresh and lovely for two or three months.

I quote from Kerner the following list, which, however, needs still further testing:

"The flowers of the *Hibiscus prionum* persist only three hours, the night blooming cereus (*C. grandiflorus*), seven hours . . . the *Geranium pratense*, two days; the *Digitalis purpurea*, six days; the *White lily*, six days; the *Striped Pelogonium*, seven days; the *European cyclamen*, ten days; the tropical

orchid, *Cattleya labiata*, thirty days; the *Phalaenopsis grandiflora*, 50 days; and the *Odontoblossum rossii*, as much as 80 days." Thus we see that the duration of the blossom varies greatly even in plants which are closely related to each other.

Thus, while there are many orchids, whose blossoms persist uncommonly long, there are others which remain fresh only a few minutes, or perish at most within a day.

The Effect of Fertilization.—In many cases this varying persistence of the blossom seems to depend upon the chances of fertilization under the conditions in which the plant grows—when these are abundant the plant does not "need" to persist very long; when they are few as among the orchids the long continued persistence of the blossom is favorable to fertilization. However, this rule must not be regarded as of universal application. . . . In some cases the withering at the end of a definite time is based upon unknown *internal* conditions: it is probable that the conditions which control senescence are inherent in certain plants, while in others we may assume that the post-florescence is controlled by a correlation of processes with those taking place in the other parts of the plant—though as yet we do not know what these processes are.

Flowers as Room Decoration.—The knowledge of the conditions that govern the fading of flowers is of much importance when the latter are used to decorate our dwellings. Naturally, those which persist at least a few days are preferable to those which are more ephemeral. . . . It must be remembered, however, like all other vital phenomena, that the fading of flowers is strongly influenced by external factors, especially by heat or cold. . . .

Much more remarkable is the fact that many flowers are capable of fading *prematurely, i.e.*, long before the given persistence for a given temperature has been reached. In such cases external factors are responsible. . . .; the most important of these is the pollenization and fertilization of the blossoms.

Thus, for example, the large white blossoms of the orchid *P. amabilis* whose unfertilized flowers remain in blossom for several weeks even in the hot climate of Java, begin to close 12 hours after being fertilized. . . those of other tropical orchids within a few days; the corolla of the borage fall from 2 to 7 hours after fertilization . . . and those of the erodium within an hour. . . .

Let us inquire into the nature of the influence thus exerted. Certain experiments made by me from 1909 to 1911 give a definite answer to this question—they show that the persistence of the blossom may be strikingly abbreviated by entirely different external influences. Thus the flowers of a number of those tropical orchids, which are caused to wither prematurely by fertilization and *only* those (no others and no later) perish when the stigma is wounded even slightly by piercing or cutting or by the brushing off of its papillæ. In the same manner the petals of the *erodium manescavi* drop off in from 40 to 80 minutes if the stylus be squeezed by a pair of pincers. . . . In all these cases injuries to the other parts of the blossom, even of the petals themselves, are entirely without effect. Such wounds, naturally, which are made at a distance from the perishable parts of the blossom, can, naturally operate only through some sort of influence exerted by the local wound, *i.e.*, of the stigma or the style . . . . Such an influence whether of chemical or other nature must be regarded as we shall see, as being a form of irritation. . . .

For example, the stigma or rather the upper part of the style appears to be the most favorable *organ of perception* for the irritation produced by the wound in the case of the orchids cited above. . . .

Other influences operate to cause premature fading much more rapidly however, than the wounding of the stigma or the style. . . . Thus I have been able to demonstrate that a sudden heating of the corolla of the geranium *pyrenaicum* and many other species, to from 33-34 degrees centigrade, causes them to fall. . . within a few minutes or even seconds—and the older the flowers the sooner they fell.

On the other hand such a sudden heating had no influence upon other flowers, such as roses and poppies. . . Furthermore, chemical influences were surprisingly effective in the case of some flowers, *e.g.*, carbon-dioxide in certain conditions, even in such small quantities as those contained in exhaled human breath—and this in some cases within a few minutes or even ¾ of a minute. . . . But in other cases carbon dioxide exerted no effect even in much higher degrees of concentration. . . . Illuminating gas was likewise found to be effective, but more slowly (though even immeasurable traces exerted an effect); other substances exerting a withering effect sometimes in very small amounts are tobacco smoke, fumes of chlorine or ether—also highly concentrated fumes of hydrochloric acid.

These various experiments indicate that different flowers vary greatly in their sensitiveness to a given irritant. Another remarkable fact is that certain blossoms fall very soon as a result of violent shaking.

In all the influences mentioned it is a general rule that the petals of the oldest flowers are the first to fall. . . . And in all these cases it is not a *vital process* but an *irritation* that is concerned. Furthermore, the irritation may be too feeble to operate—also there is a culmination of irritation, a latent period, and a possibility of becoming accustomed to the irritation; in short all the characteristic features of irritation processes are present. . . . Similar irritations have been observed to operate in the case of foliage. . . .

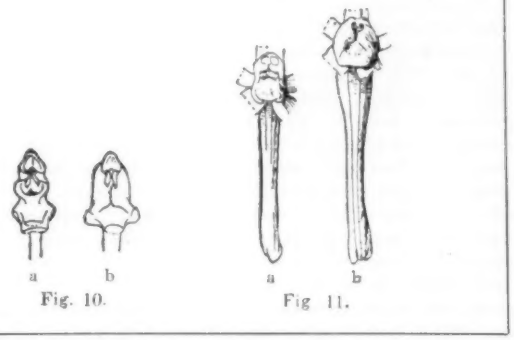


Fig. 10. Fig 11.

10: Phalaenopsis amabilis, front view of style; *a*, before pollination; *b*, six days after. 11: Arachnanthe sulingi (a species of orchid); *a*, front view of ovary and style before pollination; *b*, ovary seven days after pollination

It is evident from our experiments that fertilization itself acts as a sort of irritant or stimulus. But the question remains as to what part of this complex process constitutes the actual irritant—and this remains obscure even after a careful analysis: Thus the germination of the pollen grain often begins in a few minutes with the formation and penetration of the pollen tube into the ovary, where the ova are fertilized.

[We are obliged to condense a portion of Professor Fitting's article at this point, both because of our space limits and because of its technical nature, which consists largely of a detailed discussion pro and con of the question as to whether the phenomena of post-florescence are directly due to the fertilization of the ova by the pollen tubes. We may state in brief that while the actual fertilization of the ova does induce the phenomena of post-florescence, these can be produced within a certain limited extent by the ungerminated pollen or even by dead pollen, as well as in certain cases by a pollen from a plant of a different family which is, of course, incapable of fructifying the ova.

As a result of these various observations and experiments by himself and other investigators, Professor Fitting was led to the remarkable discovery that in certain cases the post-florescent changes are due to the presence of ***hormones*** such as have long been known to be operative in the animal economy.—EDITOR.]

THE EFFECT OF PLANT HORMONES

These effects (the withering of the corolla, the swelling and lengthening of the ovary, etc.), are due to a substance which is present only in the pollen, and which clings to the latter externally; this organic compound, which is obviously not strictly specific in operation, is readily soluble in cold water and somewhat more difficultly soluble in cold alcohol, while it is quite insoluble in chloroform, petroleum, ether, and sulfuric ether; it cannot be precipitated by lead acetate and is, to all appearance, quite free of nitrogen.

This discovery gave certain proof for the first time that the substances known as hormones, which play so great a part in the animal organism, likewise exert a definite stimulus in one of the processes concerned in plant development.

Later observations, however, indicated that this fact which was discovered by me in my studies upon orchids, is not of general application. In other words that the ungerminated living or dead pollen does not exert a similar effect in the case of all plants.

An interesting observation was that the hormone present in the ungerminated pollen acts upon the corolla in a manner similar to the wounding of the surface of the stigma described above, *i.e.*, that it operates at a distance through the style, whereas the germinated pollen tubes are incapable of causing the swelling and growth of the ovary in this manner, as is shown by the fact that they do not produce this effect when prevented from passing through the lower portion of the pistil channel into the ovary.

From all these observations we may gain the practical knowledge that the longer we desire to enjoy the beauty and charm of flowers in our dwellings or elsewhere, the more careful we must be to protect them from all those influences whose effect is to make them wither prematurely. Among these influences we must include, as stated above, pollenization, traces of illuminating gas, tobacco smoke or air exhausted by breathing, too strong and sudden a heating in the sun, etc.; with respect to pollenization it must be remembered that one way of preventing it is to exclude the visits of humming birds, butterflies, bees, and other insects, whose special function, so far as the plant is concerned, is to secure the arriving of the pollen upon the surface of the stigma.

In connection with the above consideration the important question arises as to whether there is any means of *lengthening the specific absolute persistence of the blossom*. The beautiful orchids of our hothouses give an answer to this question. It is a very remarkable fact that there are some species of this family . . . in which the *same influence* which produces a premature withering in the case of other flowers, namely, the act of pollenization, considerably lengthens their absolute persistence. . . In various species of orchids studied by me, the result produced by pollenization was to cause the blossoms to remain fresh much longer, exhibiting no signs of alteration—*i.e.*, neither closing, withering, nor changing color—than in the case of non-pollenized flowers. Thus I was able to extend the duration of the *Zygopetalum* from one to three months and other species for double their usual time.

It is especially noteworthy in this connection that this effect was produced only by living and germinating pollen, whereas dead pollen, on the other hand, prematurely shortened the duration of the blossom. Here we have an instance of a prolongation of the life—not indeed of the entire organism—but at any rate of a portion of it, which is accustomed to undergo partial death.

This raises the further inquiry as whether it is possible to actually arouse new life in portions of the flower, which having arrived at the end of a specific absolute existence, have begun to show symptoms of morbidity—a question which has long occupied man with respect to his own body. As a matter of fact I succeeded in 1910, at least in the case of one species, the *Epidendrum ciliare*, in arousing new vital activity in the style (which had already begun to wither and yellow) by pollenization—*i.e.*, I caused it to swell and grow green once more, thus prolonging its existence for a considerable length of time.

The case appears to be quite similar with the above-mentioned blossoms of the *Phalaenopsis violacea*: When pollenized with living pollen the corolla begins to close, turn yellow, and to wither slightly, evidently under the influence of the hormone in the ungerminated pollen acting upon the stigma; but a few days later the corolla again becomes firm and fresh, begins to become green and renews its growth evidently under the influence of the pollen tubes which have been meanwhile produced or as a result of actual fructification.

PLOTTING THE SURVEY

THE roll of paper is taken off the instrument and cut up. Each sheet is gone over and the inclined distances reduced to horizontal by means of a traverse table; the horizontal distances being marked in red ink against each line.

A large piece of cartridge paper is pinned down on the drawing table and the paper disks from the instrument are tacked down to it by means of a spot of gum at each corner, a lead weight being left on the corners for a few minutes until the gum dries. Gum is more satisfactory than pins, as there is nothing to interfere with the parallel ruler.

A rolling parallel ruler is placed against the first line S.W. to 1 and run out to a suitable place on the paper, a line ruled and the distance scaled off (scale in this case 1:100) and so on with all the lines of the survey.

The traverse lines are traced off on a piece of tracing paper, which is placed over the working stope sheet with the survey nails and check marks coinciding; it is then held in position by weights, the offsets are plotted along each line and pricked through to the stope sheet. Any new check marks are also pricked through. The tracing paper is taken off and the pinpricks on the stope sheet joined up with a hard pencil. The heights are averaged up in sections and marked on the stope sheet.

The area of each section is taken out by an Amsler planimeter and marked on the sheet. The cubic contents of each section is calculated to the nearest meter, and the various sections added up.

This method of surveying is rapid and gives results quite accurate enough for the purpose. On a trial closed traverse on the surface on fairly level ground, with a periphery of 318 m. the closing error was 0.15 m. as close as could be scaled.

The weak point of the instrument as at present constructed is the method of taking vertical angles. One or two elementary points need special attention: (1) always to make sure that the marked end of the alidade is pointing in the direction of the survey; (2) after sighting, to be certain that the alidade is clamped; (3) to mark the numbers of lines on the paper in the direction of the survey, that is, on the right-hand side of the alidade and with the tops of the letters as close to its fiducial edge as possible, so that, in the event of forgetting to draw the line, it can still be platted by placing the parallel ruler against the tops of the letters.

The survey party consists of the surveyor, three picked native assistants and a boy. The second assistant goes on in front and sets up and levels the tripods; the surveyor stays by the instrument and carries it himself from tripod to tripod. Two assistants are required to hold the tape from tripod to tripod, while the chief assistant and the boy take the offsets to the face, which the surveyor notes.

While the surveyor is working underground, an assistant in the office is plotting the previous day's work. Two notebooks are used alternately. The working stope sheets (of which there is one for each stope) are 1:100.

This method of stope surveying is twice as rapid as the method it superseded, and more than twice as rapid in the plotting, besides being more accurate and involving less strain on the attention of both the surveyor and his assistants. It was used by the writer for all stope measurements at the Passagem mine from 1916 to 1919.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

MENTAL TESTS AND MANUAL LABOR

In the *Journal of Applied Psychology*, December, 1920, Mr. Arthur Otis, in an article on "The Selection of Mill Workers by Mental Tests," presents some surprising results.

At the close of his army service he installed a system of mental tests for prospective employees (both clerks and mill workers), in a silk manufacturing company. Bringing to bear this experience in mental testing in the army and schools he constructed two systems of intelligence tests, one for clerks and executives, similar to the Otis General Intelligence Examination, and a comprehensive performance intelligence examination somewhat similar to the performance tests used in the army for foreigners and illiterates. This latter was for all mill workers, a large percentage of whom were foreign or illiterate.

The clerical intelligence test proved to be of decided value in the selection of members of the office force and has been adopted for permanent use. The results of an extended tryout of the performance intelligence examination, however, are both startling and baffling and cast an ominous shadow over the future of strictly intelligence tests for manual workers.

The performance scale used in this connection consisted of 13 tests covering a wide range of mental and manual activity. The examination of an individual lasted on the average an hour. In all some 400 employees were tested. These were placed in three groups according to their productive ability ascertained by careful investigation. In the last analysis it was found that the correlation between intelligence and productive ability was zero! No amount of age grouping or length of service grouping would bring anything but zero out of the correlations..

Commenting on this result the writer says: "The tests did measure intelligence one may be perfectly confident. The ability of clerks in these tests were found to be distinctly above that of mill workers as a class. The intercorrelations between the several tests ranged between .40 and .75 denoting a 'reliability coefficient' for the whole scale of .97. When 13 widely varying tests tend strongly to measure the same ability that ability must be 'general ability' or intelligence."

Mr. Otis is not prepared to say that it is proved conclusively that there is no correlation between intelligence and efficiency in mill work, for various reasons. It cannot be asserted confidently, he says, that every examinee did his best on the tests. There was lacking the incentive that is present when an applicant seeks employment. These examinees were already employed and saw no purpose in the tests. Moreover, the rating in productive ability was not as refined as could be desired due to numerous difficulties which could not be overcome in making the ratings. Furthermore, it was not possible to test such individuals as had failed to learn to weave or spin or be worth employing in some branch of the industry. These might have shown a lesser intelligence as a group.

On the other hand the difficulties above mentioned are only such as would be expected to "attenuate" the correlations—to reduce the true correlations to, say, one-half or less. But a correlation must be pretty small in the first place if one-half or one-third of it equals zero! One is forced to conclude, therefore, that intelligence is a very unimportant factor in efficiency in silk mill work.

The psychologist can hardly rest content with such a conclusion without some sort of explanation, considering the known correlation between intelligence and clerical ability or executive ability, military ability, etc.

The conclusion drawn from these researches is that intelligence is not only not required for most operations in a modern mill, but may even be a detriment to steady efficient routine work. What qualities are required remains to be sought. They may be stolidity, patience, inertia of attention, regularity of habits, etc.

The field of industrial psychology as applied to manual labor is believed by Mr. Otis to be virgin soil.

GEOLOGIC CONCLUSIONS FROM GEODETIC DATA

In the Proceedings of the National Academy of Sciences for January, 1921, Mr. William Bowie directs attention to Some Geologic Conclusions That Are Derivable from Geodetic Data.

For a number of years, says Mr. Bowie, geodetic data were collected for the purpose of controlling surveys and maps and for the determination of the shape and size of the earth. But in recent years they are also extensively used in investigations dealing with geological and geophysical problems. These investigations have included data for the United States, India, Canada and a small part of Europe.

These investigations have proved that for the areas considered there is approximately the same mass in each column of unit cross-section extending from the surface of the earth down to a depth of, say, 75 miles. This statement is justified regardless of what the depth of compensation actually is, for the deficiency or excess of mass in a few miles at the depth of approximately 75 miles is a small percentage of the mass of the whole column. There is no evidence as to the manner in which the compensation is distributed vertically, but the uniform distribution, which was adopted in order to make the computations more feasible, is as logical as any other simple method.

Continuing, Mr. Bowie says that it has been found that large areas are in almost perfect isotatic balance, and that it seems to be very probable that an area of about 70 square miles, the area of one square degree at the equator, is very closely compensated.

A test was made to show whether the compensation of small areas of topography could be ignored without seriously affecting the results. This test shows that, for even very small areas, the topography is at least largely compensated. This is a most important conclusion, for by analogy no such mass as the sedimentary material forming the delta of a large river entirely escapes isotatic compensation as has been held by some investigators. It may be concluded that the evidence *available from geodetic investigations* indicates in the strongest way that land masses are in equilibrium and that this equilibrium exists in comparatively small areas. A natural inference is that land masses have been equally in equilibrium in former geologic periods.

"How then," asks Mr. Bowie "can an area of sedimentation at approximately sea level, of one age, be a mountainous area in a succeeding one?"

Discussing this question, he says: "Mountain formation by transportation of material horizontally from one column in equilibrium to another column in equilibrium could not take place without destroying the isotatic balance. Of course, material is transported from one column to another (surface transportation after erosion is not included in this statement) but this is when the columns are out of balance and the movement renews the isotatic equilibrium between the two columns. Mountain masses are not excess loads on the earth, as is proved by the existence of the isotatic conditions in mountainous regions, therefore the materials forming the moun-

tains were not moved horizontally to the region. We are forced to the conclusion that the mountains must result from vertical movements in the columns under them. The vertical movement evidently must be due to an expansion and consequent decrease in density in the material of the column."

And further: "When we consider that all extensive areas of recent sedimentation on which we have gravity stations are in isotatic equilibrium and that mountain systems formed in previous sedimentary areas are also in equilibrium, we have no alternative to the view that an actual expansion of the columns under the mountains has taken place.

"The objection will be raised that there is abundant evidence that there have been horizontal movements in the materials forming the mountains. This is granted but is it necessary to go far beyond the mountain area for the forces acting laterally which cause the observed horizontal movements? Can we not conceive that, in the uplifting of the mountains of the Appalachian and Himalayan systems, for instance, the vertically acting forces will cause the material to progress in the directions of least resistance and that these directions may be horizontal in some cases and in others at varying angles with the vertical?"

The conclusion is reached that during the period of sedimentation, material probably was laid down in irregular ways. In the process of uplift the rate of expansion would undoubtedly be different in different parts of the zone. The sediments being of varying thickness, the material on which the sediment has been deposited varies in composition and consequently in its resistance to uplift. Finally, there is cubical expansion of the material which must cause the material at the borders, but outside of the columns, to modify somewhat the upward movements of the expanding mass. The areas affected are not small for the area of the base of the Appalachian system is more than 1000 miles in length and is approximately 200 miles in width, on an average. Consequently, there seems to be sufficient space for the development of lateral movements within the area due to local causes.

THE MENDELIAN LAW AND TOBACCO

IN the proceedings of the National Academy of Sciences for February, 1921, Messrs. Setchell, Goodspeed and Clausen gave an account of crossing certain varieties of *Nicotiana Tabacum*. The authors find that their results confirm the Mendelian principles of inheritance, and show that there is no difference between qualitative and quantitative characters.

In connection with a taxonomic study of the various species and varieties of *Nicotiana*, the authors became interested in the extremely varied assemblage of varieties, both botanical and commercial, included under the species *N. Tabacum*. They agreed in principle on the method of derivation of existing varieties, but held conflicting views as to which particular forms should be recognized as fundamental. The principle followed in attempting to unravel the problem of origin of cultivated forms was to determine which few historically old varieties possessed in various combinations all the characters exhibited by commercial varieties, and then to refer existing varieties to hybridization with resulting segregation and recombination of characters exhibited in the stem forms.

There was needed some definite information as to the Mendelian details involved in character differences within the species. Accordingly three crosses were actually made and studied at some length. In some cases derivative lines were carried into the tenth hybrid generation. The three crosses, all in reciprocal, were made in 1909 as follows: (1) *angustifolia x macrophylla*, (2) *calycina x virginica* (Maryland) and (3) *alba* (White) *x macrophylla*. Detailed descriptions of the above-named varieties have been given by Setchell in a previous paper.

A general result of these investigations has been a demonstration of the complexity of difference from a genetic standpoint between any two of these so-called fundamental varieties of *Tabacum*. This result demonstrates the futility of seeking to determine affinities on the basis of *morphological* studies unaccompanied by experimental investigations. Thus, for example, there are such puzzling segregation products as the *auriculata* and *lorifolia* leaf types, the former with its peculiarly constricted leaf base, the latter with a much narrower leaf blade than either parent, coming out of the *angustifolia-macrophylla series*. Moreover, the demonstration of the existence of genetically distinct red-flowering varieties is another evidence of the limitations of purely *morphological* studies and of the errors in the determination of affinities to which such studies are subject. The studies indicate that *Tabacum* is a group species like corn, barley, oats, etc., possessing a complex series of allemorphic contrasts.

Doubtless one of the reasons why our knowledge of the details of inheritance in *Tabacum* is so meager is because of the prevailingly quantitative or semi-quantitative nature of the character differences. Even in the case of flower color, the impression given by a series of varieties arranged in order of intensity from white to intense dark red is one of graduated differences in amount of a single pigment rather than in qualitatively different pigments. A definite alternative analysis can, however, be made even for these semi-quantitative characters by growing successive generations of segregating progenies until the progenies have been freed of segregation products other than those which it is desired to analyze. Furthermore, the establishment of constant derivative races and the subsequent study of intercrosses among them has been found to result in simplification of the difficulties of analysis. Both of these methods evidently depend upon stabilizing the residual genotype, which is a prime desideratum in the accurate analysis of semi-quantitative characters. The fact that such simplification of segregation can be accomplished and that semi-quantitative characters may then be subjected to analysis according to the qualitative mode of procedure argues not only for the adequacy of Mendelian principles in these cases, but for the identity in principle of qualitative and quantitative characters.

MUSCLE

IN *The American Journal of Physiology* for May, 1921, Messrs. N. B. Eddy and A. W. Downs present an interesting paper on "Muscle, Its Extensibility and Its Fatigue." Reviewing the work bearing on their investigations the authors say in part:

"The extensibility of muscle was first systematically investigated by Weber in 1846. It was he who found that a muscle stretched by the addition of equal increments of weight does not follow Hooke's law. Its curve of extensibility is not a straight line but a hyperbola. Weber's findings have been confirmed beyond question. There are, however, some other organic substances, non-living, which do not follow Hooke's law when extended by weights. Therefore, is the muscle which is stretched by a weight purely passive, or, does it put forth an active effort to support the weight; that is, does the stretching of a living muscle involve an increase in its metabolism, an energy transformation, the doing of work?

"Guerrini considers the specific form of the curve of extensibility of muscle as affording evidence of a vital response in the muscle. He speaks of the later more gradual part of the curve as dependent upon the biological factor, arguing from the lessening or total disappearance of this part of the curve, that is, from the straightening out of the curve when the vitality of the muscle is lessened or destroyed. He cites particularly poisoning of the muscle by various means and fatty degeneration of the muscle as affecting the curve in this manner. Many observers are agreed that the extensibility of muscle is increased and that the curve more nearly approaches a straight line during contraction and with the development of fatigue.

"Brodie found that muscles *in situ* with intact nerve and blood supply were more resistant to extending forces, the

same weight caused less lengthening, than isolated muscles or muscles *in situ* whose nerve supply had been cut.

"Montgomery appears to have been the first to conceive the possibility that the stretching of a muscle may be accompanied by chemical as well as physical changes within the muscle. He did not, however, venture to reveal the nature of these chemical changes."

The authors took up the question at this point and carried out a series of twenty-five experiments with a view to determining the possible extent to which the stretching of a muscle may influence the development of fatigue.

Both gastrocnemius muscles were removed from a pithed frog as speedily as possible with especial care to avoid traction on either muscle. Each was fastened in the femur clamp of a separate moist chamber of the Harvard type and fine wires were run from the base of the moist chamber to the muscle for its direct stimulation. A pin-hook with attached thread was passed through each tendo Achillis. One was left free; the other was fastened to a muscle lever and made to support a weight of 100 grams for varying lengths of time. Subsequently each muscle was stimulated with an induced current to the point of complete exhaustion. In two instances a tetanizing current was employed; in all of the other experiments the stimuli were single break shocks. In the first seven experiments the stretched and unstretched muscles were connected in series in one secondary circuit of an induction coil so that both muscles were stimulated simultaneously. The strength of the stimulus was that which called forth maximal response in the unstretched muscle. The stimuli were sent in at the rate of one per second. The direction of the current in the secondary circuit was varied so that in some experiments the stretched muscle and in others the unstretched muscle was first traversed by the current.

The stimulation of the stretched muscle was always carried out immediately upon the removal of the weight. The muscle was always left attached to the muscle lever and sometimes additional 20 or 30 grams were suspended from it. The unstretched muscle was connected to the muscle lever just prior to its stimulation and a load of 20 or 30 grams added if necessary to make the conditions uniform. Usually the writing point of the muscle lever was brought against the smoked surface of the kymograph and the contractions recorded. The time required to effect complete exhaustion of each muscle was determined with a stop-watch.

The results of the experiments are presented in a table, and the conclusion is reached:

These results would seem to be sufficiently marked to justify the conclusion that a previous stretching hastens the onset of fatigue in a muscle. This is not due simply to an alteration in the irritability of the muscle since the average minimal stimulus is slightly weaker for the stretched than for the unstretched muscle. Obviously there is no opportunity for the isolated muscle to replenish its store of energy-yielding material and the using up of some of this by the muscle in combating the stretching force would hasten the development of fatigue since fatigue is not only an accumulation of waste products but also an exhaustion of energy-yielding material.

BIOCLIMATICS

IN a paper published in the *Journal of the Washington Academy of Sciences* and read before the Academy of Sciences, Washington, Dr. A. D. Andrews discusses the interesting subject of Bioclimatics.

"*The bioclimatic law*," says Dr. Andrews, "Is a law of life and climate as related to the geographical coordinates *latitude*, *longitude* and *altitude*. It includes, as one of its principles, an average, or constant, rate of variation with variations in geographical positions, as manifested by the advance of the seasons and coincident phenomena, and by the geographical distribution of living organisms and types of climate."

The subject is largely one of the relations between life and climate, with regard to the original home of a species, the environments under which it has developed, the range and limits of its natural distribution on one continent, the place of its artificial introduction to another, its establishment there, and its natural or artificial spread from the point of entry.

In accordance with this law the country-wide average rates of variation in time, temperature, and distance, as related to periodical phenomena, geographical distribution, range and limits of zones, etc., are represented by the unit constants of 4 days to each equivalent constant of 1 degree of latitude, 5 degrees of longitude (or 1 degree isophane), 400 feet of altitude and 1 degree Fahr. of the thermal mean. These unit constants are equivalent, one to the other, and, therefore, the terms of one unit may be converted into those of another as required in the computation and expression of results.

The application of the law to the study of any problem relating to life or climate in which the elements and data are subject to expression in terms of quantity, as to time, temperature, and distance, falls within the category of a mathematical concept of variable nature and, therefore, in the solving of bioclimatic problems, involves the determination of certain evidence and facts by mathematical methods.

In the application of the law certain principles are involved, namely:

(1) *The principle of geographical unit constants* which relates to rates of variations or gradients of time, temperature, and distance, with variations in geographical position.

(2) *The principle of the isophane and altitude* in which the isophane is an expression of the combined unit constant of the latitude and longitude coordinates while the altitude unit constant is a measure of variation with elevation of a place above its sea-level isophane in terms of time, and equivalent units of feet, meters, thermal mean, etc. This principle is fundamental.

(3) *The principle of the sea-level constant.* This represents a uniform element of the system of computation of tables of altitude, time or thermal constants in accordance with the unit constants of the law.

(4) *The principle of the base station and base data.* This principle, in connection with that of the sea-level constant, serves as a central or basic element of a uniform system of computation and comparison of quantities.

(5) *The principle of the constant and variable.* This relates to the study of variability with reference to a "constant" as the measure of the relative intensity of the factors of variation.

(6) *The principle of equivalents* as related to equal unit values of certain elements of the law and of the system of application, such as the geographic unit constants.

(7) *The principle of the average or norm* as related to variable quantities.

(8) *The principle or law of averages* as related to the compensation of errors in reported dates of events, temperatures, general computation of data, etc.

Discussing the results of the application of these principles, Dr. Andrews says:

"In a general comparison of the results of the study as to the relations between the predictions and the actual dates, etc., it is concluded that the significance of the results of this study, is in showing not only the relations between eastern North America and western Europe, as to the relative advances of spring, but the general range of variations, of the recorded dates and thermal mean equivalents, from the dates, and from the thermal means, predicted from an incontinental base. These results indicate, as nothing else has heretofore, the amount of regional and local difference in days to be expected for a spring event between a place in eastern North America and places in western Europe.

The results relating to the prediction of bioclimatic zones represented by the recorded dates and thermal means are of special significance in indicating the zonal relations between eastern North America and western Europe and in showing that the law may be applied to the preliminary prediction

of zones of equal adaptation to certain species and varieties of plants and animals, farm and garden crops, as a guide to the successful introduction of desirable species and varieties, and the prevention of the introduction of pests from one to another part of the world. These, together with the results relating to variations in equivalent days and to the variations of the recorded from a constant thermal mean, are new.

In conclusion the writer says: "The general results of this study of an intercontinental problem in bioclimatics should leave little or no reasonable doubt as to the fact of, and prevailing responses represented by, the bioclimatic law. Neither should there be any doubt as to its practical application to almost any problem in any branch of natural science which involves a consideration of the responses of living organisms and climatic elements to continental, regional and local influences, or to problems that require a measure of the relative intensity of the factors of variations as related to periodical manifestations and geographical distributions."

THE STRUCTURE OF CRYSTALS

IN the *Journal of the Washington Academy of Sciences* for May 19, 1921, Dr. R. W. G. Wyckoff discusses methods for The Determination of the Structure of Crystals.

An outline of the developments of the methods thus far used, the author says, serves to show the point of view from which the studies of the arrangement of the atoms in crystals has been carried out. The essential steps in this development are the experiments of Laue and of the Braggs, the determination of the arrangement of the atoms in some one crystal and the consequent measurement of the absolute wave lengths of X-rays. In nearly all of the structures which have been studied a procedure based upon the point of view of these experiments has been followed. This procedure consists in getting a limited amount of experimental data with the aid of one of the three existing methods of obtaining diffraction effects—the Laue method, the spectrometer method or its modification, and the method of powders. Bearing these experimental facts in mind, the analyst has tried to imagine some arrangement of atoms which will explain them. If he has succeeded in devising such a grouping, it is considered to be the structure of the crystal. This method of procedure is both cumbersome and haphazard and there is no means of knowing whether many other ways of arranging the atoms of the crystal under examination do not exist, all equally capable of explaining the data.

Mr. Wyckoff contrasts this method with that method which can be built around the theory of space groups. The results of this geometrical theory can be given an analytical representation which states in terms of suitable coordinates all of the positions in space that atoms in crystals can occupy. With its aid, and knowing the crystallographic symmetry, it is thus possible to write down in the case of any particular crystal, independently of any X-ray experimentation, all of the ways in which the atoms can be arranged. Suitable calculation will give the kind of diffraction effects to be anticipated from each of these possible arrangements of atoms. The experimenter may then obtain, by whichever of the various methods will yield the desired information most readily, those data which the calculations show to be necessary to distinguish between the possible atomic groupings.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

HARDENING OF METALS

JEFFRIES AND ARCHER have made an important contribution upon the theory of metal hardening in their paper entitled "The Slip Interference Theory of the Hardening of Metals." The paper which is extensive and illustrated appears in full in the June 15th number of *Chemical and Metallurgical Engineer* from which the following summary is quoted:

"A complete theory of hardening must explain hardness in non-allotropic metals, a task which has been attempted in the preceding pages, and is summarized below:

"1. The inherent cohesion of the pure metals is far in excess of values obtained for tensile strength.

"2. Mechanical failure under stress is ordinarily premature because of the presence of crystallographic planes of weakness, or potential slip planes.

"3. Any structural condition which interferes with slip on these planes of weakness increases the strength and hardness of the metal. Furthermore, every known method of hardening metals can be referred to this principle of 'slip interference.'

"4. In a pure metal the most simple source of increased hardness is grain refinement, which introduces slip interference at the grain boundaries due to the different orientations of the adjacent grains, and, especially in fine grained metals, to the disorganized or amorphous metal between the grains.

"5. Cold-working introduces slip interference by the fragmentation of the grains and the production of amorphous metal.

"6. The hardness and strength of amorphous metal itself is due to the absence of the planes of weakness characteristic of crystals.

"7. Slip within grains is opposed by the presence of a strong constituent at the grain boundary, providing that if the strong constituent is brittle, its shape and size are not such as to lead to effective weakness due to eccentricity of loading.

"8. Effective hardening is obtained by slip interference within the grains, due to the presence of hard constituents uniformly distributed in the form of very fine particles.

"9. It is not necessary that the hard constituent possess great adhesion for the matrix.

"10. The effect of a given amount of hard constituent increases with the fineness of subdivision, reaching a maximum at an average particle size denoted by the term 'critical dispersion.' The critical dispersion probably consists of the smallest particles having the characteristic properties of the crystalline substance. The order of magnitude of the diameter of such particles is probably about 10^{-7} cm. A higher degree of dispersion, particularly the atomic dispersion of solid solutions, is less conducive to hardness.

"11. Corresponding to the maximum hardness at critical dispersion, there is a minimum in ductility.

"12. Increase in the amount of dispersed substance produces increased hardness, but the brittleness also increases, so that there is a limit to the useful hardness and strength that can be obtained.

"13. The amount of hard dispersed substance which produces the greatest useful strength increases as the size of particle increases.

"14. The actual amounts of hard dispersed substances which produce useful results are from about 2 to 15 per cent by volume.

"15. The only manner in which the high degrees of dispersion desired are produced consists in the limited decomposition of solutions, and in particular of solid solutions.

MICROANALYTICAL METHODS IN OIL ANALYSIS

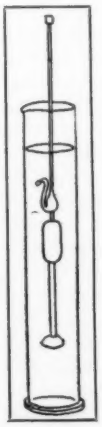
MICROANALYSIS presents so many advantages that it seems remarkable that more attention has not been given to developing its technique, considering its field of usefulness. There have been a few outstanding investigators who have devoted years to this subject; but the average analyst is too prone to call for larger samples of an unknown and is too little interested in the development of methods whereby a reduction in the quantity required for analysis can be secured. In many cases the quantity available for analysis is distinctly limited. It is therefore interesting to note the work reported by Gill and Simms under the title "Microanalytical Methods in Oil Analysis," which has just appeared in the June issue of the *Journal of Industrial and Engineering Chemistry*. The authors show that an accurate proximate analysis may be made upon oil when only a few drops are available and that this work can be done with an accuracy comparable to that obtained by the usual methods.

Four oils of widely different properties were selected, these being olive, lard, cottonseed and raw linseed, and the tests to which most attention was given were the iodine number, saponification value, and specific gravity.

Those interested should consult the original article for details. Very close analytical results on the saponification and iodine values of oils are obtainable with 15 milligrams of the sample or about 1/100 the usual amount required for the first determination, and 11 milligrams, which is from 1/14 to 1/27 of the usual sample for the second determination. Good results for specific gravity are obtainable with one gram samples and the apparatus used throughout the experiments was that ordinarily to be found in the laboratory or easily made by a good manipulator.

The extent to which the investigators carried their work is shown by the attempt to make two or more determinations on the same drop of oil. For example, it was thought that it might be possible to get the refractive index on a drop or two of oil, absorb the oil on filter paper, obtain the saponification value, and then get the melting point of the fatty acids and their iodine value. However, no success attended these attempts.

In specific gravity work a new type of hydrometer was devised, consisting of two bulbs, the lower one being the usual hydrometer bulb while the upper one, not connected with the lower, is to be filled with the oil or other substance whose gravity is desired. This bulb has a small side tube which is dipped into some of the substance placed on a flat watch glass and the sample is then drawn through the stem, which is open at the top. The bulb is filled to a little above the mark on the stem with the liquid which is then drawn down to the mark by means of a piece of filter paper applicable to the end of the short tube. A soft rubber stopper with a small hole in it is then placed on the end of the stem to prevent the entrance of water in the bulb by capillary attraction when the bulb is immersed in water. The bulb having been filled with the oil the hydrometer is immersed in water in a two liter graduate. The height of the hydrometer in the water is observed by reading on the scale of the graduate the height of the bottom of the hydrometer. In this way it is not necessary to calibrate the stem of the hydrometer and a smaller stem may be used. This is important since the sensitiveness of a hydrometer may be taken as inversely proportional to the diameter of the stem squared. Hence to make a hydrometer sensitive it is necessary to make the stem as fine as practicable.



The bulb is emptied by blowing through the stem and is rinsed out with alcohol and ether.

The method is very simple and no weighings are required. The chances of error are smaller, since there is always danger of a large error in weighing a glass vessel, owing to the absorption of an appreciable layer of moisture, the amount depending upon the humidity of the atmosphere. When the hydrometer described has been calibrated by filling the bulb with water, taking a reading, and then reading it with oil of known specific gravity and calculating a factor for the hydrometer in use, one reading is sufficient. The only source of error lies in reading the scale, provided only that care is exercised in filling the bulb exactly to the mark on the stem and there is not too much variation in temperature. The error in reading the scale on the cylinder is negligible if the gradations pass all the way around the cylinder. The time required was found to be less than that which is necessary in the use of a pycnometer and, as in the latter case, the oil may be recovered and used for other determinations. The authors have given the name of gravitometer to this new piece of apparatus.

STORAGE AND DEHYDRATION OF VEGETABLES

GORE AND MANGELS of the Bureau of Chemistry of the United States Department of Agriculture have contributed two articles in the June number of the *Journal of Industrial and Engineering Chemistry* which will be of interest to those concerned with the storage and dehydration of vegetables. It has been found that the moisture content of dehydrated raw vegetables is a factor of considerable importance for successful storage even in airtight containers at ordinary temperatures. A series of experiments was undertaken to determine the critical moisture content for several important dried vegetables below which the changes in color and flavor, on keeping at ordinary temperatures, are very slow. These experiments were begun in 1917, some of the material being dried early in 1918, and included carrots, turnips, onions, spinach, and cabbage.

Carrots of 11.11 per cent moisture faded distinctly during sixty-eight days' storage while those of but 7.39 per cent moisture kept well for the same period. Turnips of 11.51 per cent moisture browned distinctly and developed a peculiar odor in thirty-three days while those dried to 5 per cent moisture had not changed in eighty days. The same general facts were confirmed in the case of the onions, spinach, and cabbage.

The initial moisture content at and below which the distinctive color and flavor are well retained for six months or more were found to be as follows:

Carrots	4.99 to 7.39%
Turnips	5.00%
Onions	5.74 to 6.64%
Spinach	3.81 to 5.38%
Cabbage	3.00 to 3.34%

The effect of heat on different dehydrated vegetables has also been investigated, the object being to determine, if possible, limits of tolerance for different vegetables and also to determine the importance of three varieties: first, the degree of heat used; second, the time of exposure to this temperature; and third, the relative humidity of the surrounding air. The dried vegetables studied were classed as follows in regard to sensitiveness to heat:

Very easily injured: Onions, turnips, celery, tomatoes, cabbage.

Fairly resistant: Carrots, string beans, sweet corn.

Very resistant: Sweet potatoes

As the degree of temperature increases the exposure necessary to cause injury decreases, and an exposure in an atmosphere of comparatively high relative humidity at the lower temperatures was found to be more injurious than the same exposure in a dry atmosphere. The following detailed results of these experiments is quoted:

String Beans.—No injury resulted from 18 hours' exposure to dry heat at 55° C., and injury was doubtful at 60° C. Moist heat caused no injury in 20 hours at 50° C., but injured the beans in from 9 to 11 hours at 60° C. At 90° C., both dry and moist heat injured the beans within 1 to 2 hours.

Cabbage.—In dry heat, cabbage was injured in 16 to 20 hours at 50° C., in 12 to 14 hours at 55° C., in 3.5 hours at 70° C., and in 1 hour at 75° C. In moist heat, injury occurred in 6 to 8 hours at 50° C., in 5 hours at 60° C., and in 3.5 hours at 70° C.

Carrots.—Carrots are not easily damaged by overheating, and in this respect are comparable to string beans. Moist air at 50° C. injured the carrots in from 17 to 18 hours, while at 60° C. injury occurred in from 8 to 9 hours. In the dry atmosphere no injury occurred in 18 hours at 60° C. At 65° C., the product was injured in from 10 to 12 hours. The moist heat curve was consistently below the dry heat curve and gradually approached it at higher temperatures.

Celery.—Celery may be classed with the easily injured vegetables. In a moist atmosphere at 50° C., injury occurred between 6 and 8 hours. In a dry atmosphere, no injury was found at 20 hours' exposure. At 60° C. injury occurred after 4 hours' exposure. The moist heat line was consistently under the dry heat line to 80° C., where they coincided, injury being found after 30 minutes' exposure. The observations coincided again at 90° after 10 minutes. Celery is especially susceptible to color changes in a moist atmosphere at low temperatures.

Onions.—Onions are very susceptible to heat, both dry and moist. In a dry atmosphere, the injury occurred after 12 to 16 hours' exposure at 50° C., while in a moist atmosphere injury occurred after 8 to 10 hours at this temperature. Injury occurred in 6 hours in a dry atmosphere at 55° C., and in 5 hours at 60° C. In a moist atmosphere at 60° C. injury occurred after 4 hours. From 70° up to 90° C., dry and moist heat had about the same effect. Injury occurred very quickly (in 10 minutes) at 90° C.

Potatoes—Shredded and Blanched.—Potatoes are not especially susceptible to heat injury. The injury is very easily detected on account of the light color and translucence of the pieces. Moist and dry heat had about the same effect, except at the lower temperatures. In dry heat injury occurred after 16 hours' exposure at 50° C., in 11 hours at 55° C., and in 8 hours at 60° C. In a moist atmosphere injury occurred after 11 hours at 50° C., and in 7 hours at 60° C.

Potatoes—Diced.—Diced potatoes have almost the same resistance to heat as the blanched, shredded potatoes. The end-point is not so easily distinguished.

Sweet Potatoes.—Sweet potatoes are very resistant to heat, as compared with the other vegetables. In a moist atmosphere at 90° C., injury occurred in from 8 to 12 hours. No injury after 10 hours was found in a moist atmosphere at 80° C. In a dry atmosphere at 90° C. injury occurred after 5 hours, and after 10 hours at 80° C. Temperatures lower than 80° C. did not seem to injure sweet potatoes, at least not for many hours.

Sweet Corn.—Sweet corn is fairly resistant to heat, being more resistant than carrots, although not so resistant as sweet potatoes. Moist heat in general is more harmful than dry heat. In a moist atmosphere at 50° C. no injury was found after 20 hours' exposure. In a dry atmosphere at 60° C., no injury was found after 20 hours' exposure, while in a moist atmosphere at this temperature the product was injured by 10 hours' exposure.

Tomatoes.—Tomatoes are easily injured by heat at 60° C. and above. The peculiarity of the tomato results was that at 70° C. and above moist heat was less injurious than dry heat. At 50° C., tomatoes were injured by between 8 and 10 hours' exposure in a moist atmosphere, while they did not show injury until after 16 to 18 hours' exposure in a dry atmosphere. The resistance to dry heat decreased rapidly, however, as the temperature rose, and at 60° C. injury occurred after 6 hours' exposure.

Turnips.—Turnips are easily injured by heat, and may be classed with celery, onions and tomatoes. At 50° C., in a moist atmosphere, injury occurred after 8 to 10 hours' exposure, while with a dry atmosphere they had to be exposed 16 to 20 hours before injury was noticeable. The resistance to dry heat decreased very rapidly, however, and at 60° C. the material showed injury after 5 hours' exposure.

CREOSOTED WOOD SILOS

THE wood-preservation studies at the Forest Products Laboratory have shown that the value of wooden silos can be greatly increased by proper treatment with coal-tar creosote. A good creosote treatment will not only increase the durability of the wood, but will reduce the tendency of the staves to shrink when the silo is empty. A creosoted silo cannot be painted afterward; however, it does not need painting for the creosote protects the wood, and its color is pleasing.

Highly durable woods, such as heart cypress or redwood, do not need protection against decay so much as the non-durable woods, but a thorough creosote treatment will make the non-durable woods, such as sap pine, last longer than durable species will without treatment.

Contamination of the silage by creosote from the staves need not be feared. This is borne out by experiments and by careful inquiry among the many farmers who have used creosoted silos. In order to be quite sure, it is well to allow the creosoted staves or the finished silo to stand a few weeks before filling.

The most thorough creosote treatment can be given by pressure methods. If pressure-treated wood is not available, very good results can be obtained by the hot and cold bath treatment. If a good penetration of coal-tar creosote is obtained by either of these processes it is not too much to expect the silo staves to resist decay 25 or 30 years.

Other methods of creosoting, such as painting, spraying, or dipping can be used. They are less costly than the pressure treatment, but they are also less effective. They will probably add several years to the life of the silo and thus pay for themselves, but the more thorough treatment should be used wherever possible. Instructions for treating silo staves by these various processes may be obtained from the Forest Products Laboratory, Madison, Wisconsin.

GLOVE CLEANING AND DYEING

O. S. BAGGER in the *National Cleaner and Dyer* gives practical information on how to obtain good results when cleaning, tinting, and dyeing gloves or other leather articles. Gloves are cleaned either by machine or by hand. Depending upon the condition of the material the gloves are thoroughly washed in a strong solution of soap from half an hour to an hour. Gray and brown gloves, lined gloves, and gauntlets are always brushed by hand. After this washing those which have perspiration stains, or are still stiff, or soiled, are then brushed with wood alcohol until the stains are gone or, in case they are very soiled, they are immersed in the alcohol and rubbed between the hands until soft, or benzine and soap is used with the alcohol. The alcohol is then removed by a further washing in soap and water. Ink stains, if present, are removed by alternate treatment of the spots with ammonia and oxalic acid dissolved in alcohol, with a final washing in alcohol to remove every trace of the acid.

Next, the gloves are wrapped in a perfectly clean cloth or put in a bag and lightly extracted with gasoline or naptha. The drying and finishing of the gloves is important. Where a small number are being cleaned they are simply blown out with the breath, after extracting, and hung up to dry on a clean line. When dry they are rubbed very lightly with talcum powder upon cloth and then stretched and smoothed by pulling over the sharp edge of a table. Where large quantities of gloves are handled they are dried in a special contrivance for the purpose and then finished on a heated metal form. Another way is to put the gloves, after extraction, on wooden or metal glove hands which have four fingers with slots between them. The gloves are smoothed out by hand or with a clean cloth and hung up to dry on the forms, the thumb being smoothed out by the worker. When dry they are rubbed with

the talcum powder. Long gloves are better pressed under tissue paper with a warm iron.

In cleaning colored gloves some of the color will be removed no matter how careful the operator has been, and retinting will be necessary. There are a number of excellent preparations for this purpose on the market, and some cleaners find it advisable to have a number of powders in colors, in stock, such that they can be mixed to produce the desired shade on short notice. A gray powder, for example, is prepared by dissolving about two ounces of fat black in half a pint of alcohol. One liquid ounce of aniline is added and sufficient auramine until the sample shows a good dark gray. Precipitated chalk is stirred until a thick paste is formed, and this paste is left in a warm place until all the alcohol has evaporated when the mass is reduced to a powder in a mortar. From this powder any shade of gray can be produced by the addition of more white or colors, the mixing being done in the mortar to secure a uniform shade. Other colors can be produced in a similar way.

The powders are applied with a piece of cotton and, after powdering, the gloves are beaten slightly in the hand to remove any excess of powder while in the case of glazed kid they are rubbed with the hands to restore, in some degree, their original gloss.

While some object to dyed gloves because the color rubs off, Mr. Bagger gives a formula for the preparation of a dye liquor which in his experience practically eliminates this trouble. Six ounces of fat black, one-fourth ounce of yellow, and one-eighth ounce of orange, all soluble in alcohol, are dissolved in one pint of aniline oil over a fire, and one pint of methanol is added. This solution is kept in a tightly stoppered bottle and small portions poured out as needed. Gloves first cleaned in benzine and dried have the color applied by means of a camel's hair brush, each finger being treated separately on a glove stick. The penetration of the dye to the inside of the glove is avoided by using small quantities on the brush and applying it with long, light strokes. The glove, when dried, is of a grayish blue color which polishes to a good black. More than one coat is sometimes necessary. While polishing is often done with some oil, such as olive oil, this is objectionable because of the sticky, greasy feeling. A better method is to use ordinary black shoe polish, although the color of the shoe polish may rub off to a slight extent. The best way seems to be to treat the glove with a colorless dressing which may be prepared by melting four parts of wax, four parts of olive oil, and one part of lard. To this is added a small amount of turpentine and a few drops of oil of lavender. The mixture is stirred well and, when cool, forms a colorless plate which will make gloves soft and glossy and practically prevent color from rubbing off. Suede gloves are more difficult to dye; but a fair result may be obtained by using a dye liquor prepared without the aniline oil and, instead of rubbing them, powder them with a black powder prepared in the same manner as the gray powder previously described.

When dyeing shoes, as much of the original dressing as possible should be removed, for otherwise the dye cannot penetrate uniformly, and in all cases several coats will be necessary. Suede tops should be treated in the same manner as suede gloves.

Satin slippers are dyed to the desired shade with basic dyes soluble in alcohol, and the shade is first obtained on a sample of white satin. After obtaining the shade the solutions to be used are greatly diluted and a number of light coats applied, since it is practically impossible to remove any excess color. The dye is applied with a cloth, working quickly to obtain even dyeing. When dry, the slippers may be rubbed off with a cloth slightly dampened with olive oil.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

MICROSCOPIC STUDY OF GRAPHITIZATION IN CAST IRON

DURING the past year an investigation of graphitization in cast iron, designed to supplement that reported in Technologic Paper, No. 129, has been in progress. The micrographic study of the various specimens which have been subjected to prolonged annealing has been completed. The results indicate that considerable graphitization, that is change in the combined carbon, occurs in the material below the thermal critical range (approximately 700° C). Below 500° C., however, no change was detected after a very long heating period. The microscopic study reveals many interesting and valuable facts which are not brought out by chemical analysis alone. Thus, in the low-temperature graphitization, only the pearlite is affected, the free carbide does not appear to be changed until the thermal critical point has been passed and solution of this constituent has begun. The form in which the graphite exists after annealing depends upon the initial structural state of the iron. If any flakes of graphite exist they act as nuclei for the deposition of the graphite formed during annealing, while if no such flakes are present the new graphite takes the form of small globules rather than flakes.

STANDARDIZATION OF BUTTON SIZES

THERE is a real need for standardization in our button industry, and the Bureau has been looking into the question to see whether something cannot be accomplished that will lead to the elimination of useless sizes and thus reduce manufacturing costs. The possibility of eventually standardizing the materials used in the making of composition buttons is also being considered. Buttons are at present made in many thousands of patterns, finishes and colors and there are also a great many different sizes now in use. Many makers have their own particular line of sizes and grades, and in the past it has been hard for different manufacturers to match each other's product. But many in the industry feel that the specification of standard sizes, at least, is a possible step forward, that will benefit both the trade and the public, and the National Association of Button Manufacturers has requested the cooperation of the Bureau of Standards in the furtherance of this project.

There is a great variety in the sizes of buttons, ranging from an 8 line, one-fifth of an inch in diameter, to an eighty line, two inches in diameter. Instead of referring to button sizes in fractions of an inch or in millimeters, it is the custom, borrowed from England in the early days, to number them according to their size in lines, one line being considered to represent one fortieth of an inch. The Gage Section of the Bureau has obtained the size standards of several of the largest manufacturers and has evolved a proposed national standard scale which eliminates one-fifth of the usual number of sizes used by each manufacturer and discards an even larger number of the total different sizes used. Clothing manufacturers and other users of buttons will be consulted as to how the proposed changes affect their work and their recommendations followed wherever possible.

ETCHING REAGENTS FOR FERROUS METALLOGRAPHIC SPECIMENS

WORK on the above subject has been carried out on a series of 15 chromium steels, ranging in chromium-content from 0.5 to 22.5 per cent, and in carbon-content from 0.3 to 1.5 per cent, and which were all given approximately the same heat treatment (annealed at 900°-1000° C. and very slowly cooled). The results indicate that as shown by the structure developed by etching with 2 per cent alcoholic HNO_3 the number of very small globules of carbide thickly distributed through the matrix appears to depend upon the carbon-content—that is, the higher the carbon-content up to about the eutectoid point, the more numerous the carbide globules are—and to be independent of the chromium-content in excess of that needed to combine with the carbon. Etching with Murakami's reagent (solution of potassium ferricyanide and potassium hydroxide) does not appear to bring out to the same extent the presence of the very small carbide globules that etching with HNO_3 does, although the larger carbide particles are brought out to the same extent by both etching reagents.

Experimental work is now in progress to determine at greater length the extent to which the darkening of the carbide globules is brought out by etching with Murakami's reagent at room and at boiling temperatures.

In connection with the trying out of new etching reagents, it may be mentioned that a solution of potassium permanganate and potassium hydroxide (used hot) was found to give similar etching results as Murakami's reagent (used hot) with chromium and high-speed steels.

TENSILE PROPERTIES OF STEELS AT ELEVATED TEMPERATURES

THE investigation of the properties of low-carbon steel, such as is used in boiler construction, which has been in progress for some time has been completed, and the results are being prepared for publication. The title under which this paper will be issued will probably be "Effect of Temperature, Deformation, and Rate of Loading on the Tensile Properties of Low-Carbon Steel Below the Thermal Critical Range."

STRESSES IN STEEL CAR WHEELS

AT the suggestion of one of the manufacturers who has been cooperating with the Bureau in this investigation, some special "runs" were made in which strain measurements in both radial and tangential directions on both faces of the wheel were taken. The results indicated that no tangential stresses are set up in the wheel as a result of heating. On the front side of the wheel tension near the hub and compression near the rim exist, while stresses of equal magnitude, but of opposite sign, exist on the other side. This stress distribution appears to be the result of the conical shape of the wheel. Similar tests will be made on the wheels submitted by each of the other manufacturers who are working with the Bureau in these tests.

TURBIDITY OF WATER

THE Bureau is investigating the question of a turbidity standard for water supplies, at the request of the Joint Committee on Standard Methods of several of the large American technical societies. The possibility of using settling curves for the specification of the size of particles in suspension is also being considered. A report on this work was recently made before the Annual Convention of the American Water Works Association at Cleveland.

ELECTROPLATING INVESTIGATIONS

AT the recent annual meeting of the American Electroplaters' Society, three papers were presented by members of the Bureau's staff who are engaged in research on electroplating. These were:

(1) Use of Fluorides in Nickel Deposition.
(2) The Acidity of Nickel Solutions.
(3) Electrolytic Reproduction of Engraved Printing Plates.

The last-named paper described the interesting work which the Bureau has been conducting in cooperation with the Bureau of Engraving and Printing, a complete plant for producing printing plates by this new process having been installed at the Bureau of Engraving and Printing under the direction of the Bureau of Standards. The discussion of these and other papers at this meeting shows that there is increased appreciation of the value of research work in this field, and indicates that there will be a growing demand for such research from commercial electroplaters.

GLASS SPECIFICATIONS

FOR some years the Bureau has been engaged in research work dealing with optical glass and has assisted in the preparation of many specifications to govern the purchase of this material. More recently it has looked into the matter of specifications for ordinary glass-ware and has found that the need for reliable specifications in this field is just as great as in the more scientific lines. In cooperation with other government departments and the industries samples of commercial glass-ware are being obtained as well as copies of specifications, where these exist. The Bureau will examine the samples, correlate the specifications and endeavor to formulate more satisfactory ones, based on this work.

STRATIFIED SOAP FILMS AND MOLECULAR REALITY

THE properties of stratified soap films are a very striking evidence of the real existence of molecules. In the research at Paris under Professor Perrin, the black spot was shown to consist of oleic acid just two molecules thick. The thicker strata are simply superposed bimolecular layers. Results of this work were presented before the British Association at Cardiff in August, 1920, to the American Physical Society at Washington in April, 1921, and before the Physics Conference of the Massachusetts Institute of Technology at Cambridge, in May, 1921. The properties of very thin films form a fundamental part of the study of the structure of foams, jellies and similar colloids.

INVESTIGATION OF RUBBER JAR RINGS

IN the preservation of foods in glass jars, the quality of the rubber rings used to obtain an air tight joint between the jar and cover, plays an important part. For some time, in cooperation with the Bureau of Home Economics of the Department of Agriculture, the Bureau has been investigating the properties of the rings on the market, and a specification was prepared which would aid purchasers in buying only suitable rings. Recently it was decided to supplement the laboratory tests with actual canning tests to be conducted under the supervision of the Department of Agriculture. The results of the experimental work of the Bureau and the actual service tests will then be correlated and possibly a revised and improved specification will be issued.

TEMPERING OF HARDENED STEELS

AN investigation of this subject, now in progress at the Bureau, has for its object the demonstration of the structural changes which occur in hardened steels upon tempering. The work has now progressed sufficiently far to show that there is a decided change (best seen in high-carbon steels) brought about by tempering at approximately 240° C. Up to that temperature no structural change is to be seen. In all cases the changes which occur are relatively inconspicuous and this accounts for the surprising lack of data of this kind in the literature, although an immense amount of work has been done upon the subject of hardened and tempered steels.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Socitey of Mechanical Engineers

ALLOYS OF TELLURIUM WITH SOME WHITE METALS

By J. H. Ransom and C. O. Thieme

The experiments carried out covered alloys of tellurium with 50-50 tin-lead solder, with lead, tin, zinc, aluminum and zinc-base die-casting metal.

Tellurium was added to the molten metals in comparatively small percentages. When it was added to the solder it burst into a glow and then seemed to form hard lumps which only slowly and in part disappeared. No samples of these lumps have been secured for analysis.

As regards the results obtained, it was found that in some cases the addition of tellurium reduced the amount of copper in the solder. No appreciable difference was found as being due to the addition of tellurium to lead and tin, but in the case of aluminum the tensile strength increased from 13,940 to 14,810 pounds and the elongation from 18.5 per cent to 28.5 per cent. In the case of zinc, no difference in elongation was found, but the tensile strength increased from 4955 pounds to 5510 pounds per square inch. On the whole, it would appear that where metal dissolves tellurium the hardness and tensile strength are increased to an appreciable extent. In all cases investigated it is probably that tellurides of the metals are formed and that these are little soluble in the molten mass.—*Chemical and Metallurgical Engineering*, Vol. 25, No. 3, July 20, 1921, pp. 102-103.

THE MANUFACTURE OF CHARCOAL IRON BOILER TUBES

Description of the processes employed by the Parkesburg Iron Co., Parkesburg, Pa. The processes of interest, partly because of the considerable use of this kind of tubes and also because of the fact that the manufacture of these tubes has been to an unusually slight degree affected by the general processes of mechanization of modern industry.

The first stage in manufacture is selection of scrap to go into the melt. Metal containing copper, tin, nickel, chromium or more than one-half of one per cent silicon is considered to be unfit for use as these elements tend to make the finished product dry or brittle and unweldable.

The charges, in not more than 300-pound lots, are placed in small forge fires in furnaces which to all intents and purposes have not changed in the last thousand years. In a rectangular hearth about 16 inches deep by 2 feet square with a cast iron box about 3 feet high and open in the front, the charges are slowly melted in incandescent charcoal, the required oxygen being furnished by a blast of air entering the charcoal bed at about half its depth. Under the action of the blast the light scrap begins to melt and during the heating the impurities such as carbon, manganese, silicon and sulfur are slowly oxidized, a relatively large proportion of iron also undergoing the same process. The oxides unite to form a high basic slag with a comparatively low melting point and therefore quite fluid.

Gradually the mass becomes a conglomeration of microscopic grains of pure plastic iron, each covered or glazed with a film of slag.

The incandescent lump is then removed to a steam hammer where it is forged or "shingled" to a bloom about 30 inches by 5 inches by 6 inches. Before it is placed under the hammer the lump resembles a sponge with the holes filled with the molten slag and the whole covered with a husk of iron oxide and partially consumed charcoal. Under the hammer most of the slag between the grains of the iron is forced out. From the hammers the hot blooms are passed to a reheating furnace and then rolled into bars. In this process the balance of the slag is almost entirely worked out.

After cooling, the bars are sheared into the required length, reheated and re-rolled, in a two-high plate mill. The rolling is done transversely, that is, the length of the pile is parallel with the axis of the rolls. The pile is run through the mill until the length of the resulting slab is equal to the desired width of the finished plate. The slab is then turned through 90 degrees and rolled for length and thickness to give the iron cross fiber or additional strength across the grain. The metal is always rolled in the same direction and it is plain that by this method the few impurities left are worked to one end of the plate which is dropped off and a much better surface is obtained.

The plates are next trimmed into strips of the proper width to make the tubes ("skelp").

The rest of the operations do not materially differ from the manufacture of welded tubing or other kinds.—*The Boiler Maker*, Vol. 21, No. 7, July, 1921, pp. 187-190 and 212.

THE CARBONIZATION OF LUBRICATING OILS IN INTERNAL-COMBUSTION ENGINES

By Frederic H. Garner

The paper discusses the factors which cause decomposition of the oil in the engine, decomposition being considered the fundamental cause of carbonization. According to the opinion of the author, decomposition of oil in an engine can occur in two ways, namely:

First, rapid carbonization due to exposure of the oil in the form of a fine spray or mist to the explosion flame causing incomplete combustion of the oil; the result of such carbonization is the production of carbon and asphaltic material.

Second, gradual carbonization of the thin oil film on the piston and cylinder heads at temperatures of 200 to 400 degrees Cent. giving first asphaltic material which is changed to carbon by the prolonged action of these temperatures.

The paper describes experiments to determine the evaporation losses and degree of carbonization for various oils and the estimation of the asphalt resin content of lubricating oils.

Among other things it was found that the evaporation losses of lubricating oils of similar boiling point range were approximately the same whether the oils were derived from Texas or Pennsylvania crude.

It was also found that for similar oils there is a general relationship and that the higher the flash point of the oil the lower is the amount of asphaltenes formed in a given time at a given temperature. Moreover, the rate of asphaltene formation appears to follow a mathematical law and decreases almost uniformly with rise in flash point and fire point of the oil. Direct carbonization increases much more rapdly than the evaporation loss, both as regards increase of time at a particular temperature and increase of temperature after heating for the same length of time.—*Journal of the Institution of Petroleum Technologists*, Vol. 7, No. 26, April, 1921, pp. 98-126.

PHANTOM WHEEL GRINDERS

Description of the new type of grinders of American manufacture. The device was invented in the first place for grinding extremely thin pieces of hardened steel. The pieces are not absolutely flat when they come from the hardening process to the grinding operation and would not lie still under

the wheel unless packed. Packing each piece to grind first one side and then the other alternately would render the cost prohibitive, even if it were possible mechanically. A magnetic chuck could not be used because some of the pieces were so thin that even the pull exerted by each would distort them. To handle these wheels a special bearing was provided of such character, however, that there was no very efficient way of conducting the heat away from the piece being ground. Furthermore, a solid wheel wide enough to cover the surface of the work would quickly sweep the pieces off the chuck or would overheat them and a very narrow wheel that would enable the operator to avoid both these troubles would take a long time to traverse over the width of the piece, besides being likely to induce distortion because of the slow progression of the hot spot across the work.

It was to avoid these troubles that the phantom wheel was developed.

The parts of the phantom wheel are shown in Fig. 2. A standard grinding wheel 7 inches in diameter and about ½ inch width of face was first mounted in the usual manner and dressed to the shape shown in the figure, leaving a very narrow face. A sleeve was then fitted with a pair of collars, one face of each collar being machined to form an angle of about 15 degrees with its axis.

These collars are keyed to the sleeve. The lead bushing of the grinding wheel is then dug out to allow the wheel to tilt to an angle corresponding to that of the collars, a ring nut holding the whole combination together.

When the whole combination is first mounted on the grinding machine the periphery of the wheel does not run through. There are two high and two low spots. In other words, the wheel, though round of itself, will appear to be elliptical. To correct this condition the periphery must be redressed and thereafter the ring nut that binds the parts together must not be slackened, for the wheel that now presents a truly circular periphery to the work is in fact elliptic, as may be seen in Fig. 4, and as is shown by the calipers, the actual difference between the larger and smaller diameter with a wheel initially 7 inches amounts to about 3/32 inches.

The grinding action of the wheel is effectually the same as that of a solid wheel of the width equal to the scope of gyration, but the action may be represented as a series of contacts progressing back and forth across the work in a direction at right angles to its lineal advance.

When in motion, the solid lines of the wheel disappear and though the wheel is grinding with the apparent continuity of a solid wheel of 1 inch face and throwing sparks clear across the work, the work is at no time concealed from the operator's view.

Furthermore, because of the narrow surface in contact with the work at any time, comparatively little heat is generated and it becomes possible to cover the entire surface of the work without side traverse and with little danger of drawing the temper.

The original article shows a rather unusual method of dressing the wheel in which the diamond is placed at an angle of 45 degrees.—*American Machinist*, Vol. 55, No. 2, July 14, 1921, pp. 44-45.

REMOVING SCALE FROM SURFACE CONDENSER TUBES WITH HYDROCHLORIC ACID

By Norman G. Hardy

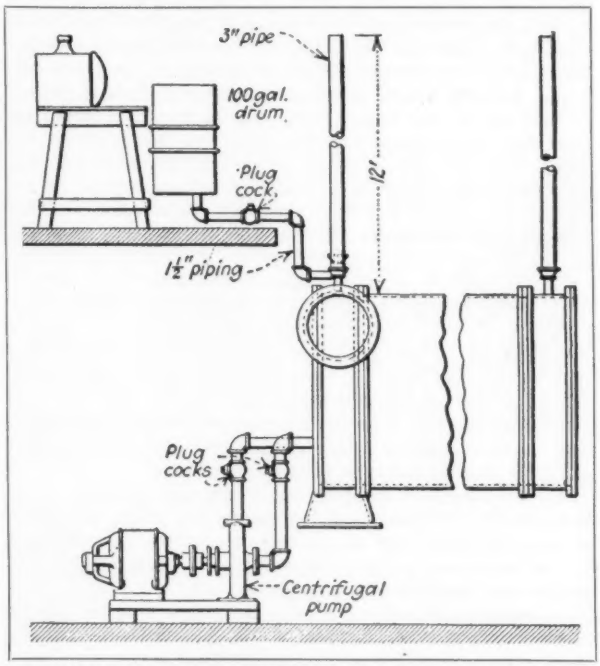
Data obtained from the practice of the Arizona Copper Co. at Clifton, Ariz., where hydrochloric acid has been used to clean condensers for the last two years. It is not claimed that this method is entirely satisfactory or that it is suitable under all conditions, but it has given very good success at the plant.

The general arrangement of apparatus is shown diagrammatically in the figure. The condensers in this outfit have a tube area of 7600 square feet in 2500 Muntz metal tubes ¾ inch in diameter by 15 feet 1 inch long. The condensers have two passes with a vertical diaphragm between water inlet and outlet compartments.

Before using the acid, both heads are removed from the water boxes, the tubes are washed out with a hose, the scale is cleaned from the water boxes, the heads, and so far as practicable, from the tube sheets also; after drying thoroughly, water boxes, heads and tube sheets are painted with two coats of roofing cement, to eliminate all chances of corrosion of the permanent parts of the condenser.

At first an acid-proof paint was tried, with the idea of maintaining a coating that would only have to be replaced occasionally, but it was found that the coating would not remain serviceable from one cleaning to the next. After trying several asphaltic paints, it was decided that roofing cement, such as is ordinarily supplied for cementing the seams of prepared roofing, was best because it is sufficiently acid resistant, can be easily applied and dries quickly.

Cover plates with gaskets are next fastened over water inlet and outlet with capscrews tapped into the water box. The heads are then replaced and the apparatus connected up as indicated in the figure. Vent pipes about 12 feet long are placed at the top of each water compartment. The water



ARRANGEMENT OF APPARATUS FOR CLEANING CONDENSER WITH HYDROCHLORIC ACID

boxes are tapped for 1½-inch pipe and have a short nipple and reducer to connect to the 3-inch vent pipe. These vent pipes are very necessary, and it has been found that gas will blow water over if a height of less than 12 feet is used. To circulate the solution a 2-inch brass centrifugal pump with direct-connected motor drive is used.

The acid used is commercial hydrochloric, averaging about 24 per cent HCl. It is estimated that the water boxes and tubes will hold 7800 pounds of water and 1000 pounds of acid is used for cleaning, making the solution about 3 per cent HCl. A stream from a ¾-inch hose is used for supplying water and the time required to discharge a measured quantity to the mixing tank is noted. From this the length of time necessary to empty one carboy of acid, with water flowing into the tank continuously is calculated. Having the outlet from the mixing tank open, the water from the hose and the acid from the carboy are delivered into the mixing tank at a predetermined rate, whence they flow into the condenser continuously until it is filled. This is a rather crude method of

proportioning the mixture, but it has been satisfactory in practice.

As soon as the level of the solution in the condenser rises above the pump suction, the pump is started. It is kept running for four to five hours, by which time the acid is entirely neutralized. The solution is usually not drained from the condenser until the following day.

The amount of scale actually dissolved is relatively small, being equivalent to a thickness of about 0.001 inch for the condenser and mixture described. But the great benefit of acid treatment is that it softens and loosens scale, so that it can easily be removed by washing and brushing. For this reason, if the condenser is very dirty, it will probably be more economical to treat it several times with a weak solution, washing out the loosened material between treatments, than to use a stronger solution.

The principal objections to the use of acid for cleaning are high cost and the possibility of injury to tubes and packing. The first of these is undoubtedly justified and eliminates this method in any case where the tubes are in good condition and the scale not too hard to permit mechanical cleaning.

With regard to the second objection, it can be positively stated that the experience of the Arizona Power Co., Ltd., for two years past does not indicate any serious deterioration of tubes as a result of the use of acid for cleaning.—*Power*, Vol. 54, No. 1, July 5, 1921, pp. 22-24.

PIPE LINE TRANSPORTATION OF HOT OIL

By Leonard L. Barrett

Discussion of effect of applying insulating coverings to hot oil pipe lines such as are found in the Californian, Texas and Mexican fields with special reference to the economic results to be obtained by such practice.

The rate of heat lost from a hot oil pipe line has a governing effect upon the location of stations. As the temperature of the oil drops, due to loss of heat by radiation, the viscosity of the oil increases rapidly and a point is reached where it becomes necessary to install a pumping station and heaters to force the oil along. The low specific heat of crude oil (approximately 0.5) accounts in a measure for the rapidity with which the oil drops in temperature during its passage through the pipe line, because for a given loss of heat the temperature of the oil will drop twice as fast as would that of water.

The chief advantage of a suitable insulating covering in the pipe line is found in the heat saving which is effected as it permits to space further apart the pumping and heating stations which form the principal element of cost in pipe line construction. It is stated in this connection that the loss of heat to the air from a pipe covered with a 1-inch thickness of 85 per cent magnesia is 0.45 B.t.u. per square foot of pipe surface per hour per degree temperature difference, while the loss of bare pipe is between 4 and 5 times as much and the ditched pipe may even exceed that of pipe in air if the ground is wet.

An extensive calculation of the flow of viscous fluids, of spacing of pumping stations and temperature of oil during flow is presented. This is accompanied by temperature distance curves, viscosity distance curves, density distance curves and calculation of thermal efficiencies obtained in practice.

As regards the coefficient of radiation, it is stated that the values given in the article for above-ground insulating lines are very reliable, likewise the values for above-ground and uninsulating lines though the latter have been determined only for still air conditions and would have to be increased for air in motion. The value of the coefficient for ditched uninsulating and insulated cannot be considered as fully reliable.

The discussion of the economic aspects of the question brings the author to the conclusion that insulation of pipe lines would bring the following net savings (based on present cost): A capital saving of $72,000 per 100 miles, an annual saving of $36,700 per 100 miles and a saving of 3.85 per cent per 1000 barrel-mile cost. To this is to be added the advantage gained through the protection of the pipe from electrolysis and the steadiness in operating conditions which is gained by eliminating all the trouble due to moist ground during rainy weather.—*Chemical and Metallurgical Engineering*, Vol. 24, No. 26.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

VOLTAGE REGULATION AND INSULATION FOR LARGE POWER, LONG DISTANCE TRANSMISSION SYSTEMS

Heretofore the distance to which power could be transmitted has been limited. The limitation is now removed by a simple method of loading the line with synchronous condensers, so that the current and voltage may be kept practically in phase. High power factor and hence high efficiency result, and the voltage rises of the system are very much reduced, thus reducing insulation strains.

A standard frequency of 60 cycles is advocated for the national system, and 220,000 volts is proposed as standard for extra large-power long-distance transmission. The system of regulation proposed will result in practically constant voltage at all points of the line at all loads. And power may be taken from or supplied to the line at any point, and the power over sections of the line or over the entire line may be reversed and the constant voltage system maintained.

A simple diagram is given, and this shows that for a 60-cycle, 220,000-volt line, the line-charging current supplies about two-thirds of the capacity current required for about 0.8 load or 320 amperes load current, and that for larger loads the synchronous condensers supply leading and for smaller loads lagging current. Thus it is seen that the transmission line has largely inherently the currents required for self-regulation, if we correct initially the power factor of the loads to near unity. Every induction motor added to the power system calls for a certain capacity current for correction of power factor to reduce the losses from motor through to the power station. Every synchronous motor added, instead of an induction motor, helps in the economy all along the line, improves the service and reduces the menace resulting from the large lagging currents. Every synchronous motor added becomes an asset to the entire system. Power factor correction should be done largely at load centers, the final correction and regulation being accomplished by the transmission line capacity current and the synchronous condensers.

The advantages of such a system are: Simpler and cheaper generators, transformers standardized for one voltage, insulation strains are reduced and a safer system results, and with constant voltage the flow of power has the greatest possible flexibility. This will give a system power transmission comparable to railway transportation, with a flexibility not possible in the ordinary system which does not have the constant voltage feature.

The problems of the line insulation are discussed, and especial attention is called to the necessity for low air and leakage resistance stresses. The leakage resistance stresses are most

important. For best results these should be distributed as uniformly as possible over the insulator surfaces, under the worst conditions. Results of a large number of tests are given. A new diagram is given which results from analysis of experimental data, from which the characteristics of insulator strings may be calculated. The wet and dry arc-over may be controlled if desired, as shown by the illustrations, but it is believed best to strive for the elimination of arcs, except for cases of accident.

While the present insulators with some form of shielding or grading (and with a system of regulation as outlined by the author) will no doubt give more satisfactory results for 220,000 volts than is now obtained on lower voltage lines, it is desirable that further work be done with a view to crystallizing the best method of handling the line insulation. There is here an opportunity for some pioneer work, which will give us all that is desired, resulting in a high factor of safety for the line insulation.—Frank G. Baum. *Journal of the American Institute of Electrical Engineers*, August, 1921, pp. 643-665.

INDUCTION DISK PHONOGRAPH MOTORS

SEVERAL makes of small commutator-type motors have been placed on the market for driving phonographs. Virtually all of these motors are arranged to operate in a vertical position and drive the phonograph disk by friction through a small pulley mounted on the lower end of the motor shaft and bearing against the outer edge of the disk. The motor described in this paper is an entirely different form and is claimed to approach the ideal more closely than any other electric motor for phonograph work. It consists of four essential parts: The stator magnetic circuit, energizing coil, phase-splitting parts and the disk rotor of nonmagnetic material. The first three generate a shifting magnetic field which produces a torque in the fourth. Motors of this type have been used for many years in watt-hour meters where accuracy is essential.

The author gives a torque speed curve; it is a straight line starting at maximum torque at standstill and finishing at zero torque at maximum speed. The maximum speed is determined by the ratio of torque to electromagnetic damping. The no-load speed is generally low, seldom over 300 r.p.m. The speed under load is determined by the amount of torque necessary; the greater the load the lower the speed. As to power, it is essentially a small power-motor on account of its low speed and poor efficiency. The power is always a maximum at half of the free speed and is of course zero at standstill and at maximum speed. Since it is an induction motor it is directly affected by a change in frequency. A given motor may be operated over a wide range of frequency.

The rotor is mounted on the main vertical shaft, the upper end of which supports the turntable carrying the record. This rotor consists of a ring of copper of about 9 inches outside diameter and is supported on a light aluminum spider. The ring is about 1.5 inches wide and revolves through a shafting field produced by field coils similar to those of the ordinary watt-hour meter. Thus, all gearing has been eliminated. A governor of the conventional type is used; it is geared to the main shaft by a silent worm wheel. Owing to the shape of the speed-torque curve, very close speed regulation is possible. Considerable difficulty was experienced in eliminating the magnetic hum, due to the 60-cycle circuit. This was finally accomplished by a proper design of the supporting brackets and spider, as well as by the elimination of vibration in the motor board itself. It was found that an aluminum spider was very much quieter than a cast iron spider when supporting the same weight of disk. The motor board is suspended by three screws, which are surrounded by sponge rubber bushings and washers.

The advantages claimed for this motor are: (1) Extreme simplicity and absence of sliding contacts. (2) Very small power absorbed in bearing friction and extremely long life. (3) The motor has been built and attached to the board as a unit, making it completely interchangeable with the spring motor, and weighs ony 7.69 pounds as against 10.88 pounds for the spring motor. (4) No damage can happen to the rotor or windings or increase in watt loss result, from stalling the motor under full voltage so that the ordinary type of friction brake may be used.—C. I. Hall. *General Electric Review*, March, 1921.

SLAG CEMENT MANUFACTURE IN ELECTRIC FURNACES

THE proposal for heating cement furnaces electrically is not new; and if it were simply a question of heat energy the electric kiln would hardly be in a preferential position. Any development will depend upon the combination of two industries, the cement industry and the metallurgical industry, by making cement on the spot where the raw materials of modern cement, slag and limestone are both available. If the metallurgist can himself make something as cement out of his slag, instead of sending his slag to the cement manufacturer, a process not looking very tempting in itself may assume a very different aspect.

Experiments of this nature have for some time been going on in the Domnarfvets Jernverk of the Stora Kopparbergs Bergslags Aktiebolag in Sweden, and the originator of the process is Mr. K. G. Wennerström, of Oxlösund. Slag, mixed if necessary with limestone or lime, is melted in a cylindrical furnace, lined inside with carbon or graphite. The massive electrode is centrally suspended in the furnace, the dimensions being so chosen that the electric resistance between the electrode and the bottom of the furnace is smaller than the resistance radially between the electrode and the furnace walls. Under those conditions the heat will chiefly be generated below the electrode, and a useful circulation will be set up. With other resistance relations the surface might be overheated. The process has to be conducted so that no electric arc is formed and the production of calcium carbide is avoided. So far the runs at Domnarfvet have been made with cold slag, *i.e.*, not with the hot liquid slag. If the slag could be charged liquid into the furnace, there to be mixed with lime and to be heated until the mixture has become homogeneous the process would be cheaper and certain difficulties would be overcome. But others would arise which are now being investigated.

The 3-ton electric furnace at Domnarfvet has a diameter of 7.25 feet and a height of 5 feet. Alternating currents of 700 kilowatts at 60 volts are introduced through one massive electrode, which has a diameter of 27.5 inches. A run takes about 10 hours. When it is finished the fused clinker of cement is tapped off and a new charge of slag and lime is added. The molten mass is not completely discharged, and the electrode is kept immersed in the liquid mass. The discharged mass is tapped into wagons and spread on a grating. When it contains much lime it crumbles into a fine flour on exposure to the air; a lump of the size of a fist will do so almost at once, luminescence and heat liberation being observed during the disintegration. Some of the fine powder does not require any grinding, bigger particles are taken to the mill. When the mass is run into water and granulated, grinding is easier than with ordinary heating in tubular kilns.

The use of the electric furnace makes it possible to prepare highly-calcareous cements subsequently to be blended with other products. The power consumption depends upon the composition of the slag and the quality of the lime, as well as upon the slag temperature. Starting from the cold slag the current consumption is high—1200 kilowatts per ton of cement, with hot slag that figure would go down to half its value. The electrode consumption is about 10 mm. of electrode length per run; the thickness of the electrode is also reduced. Slags from alloy furnaces have been utilized in addition to blast-furnace slags. The slag from ferro-manganese furnaces may contain 10 per cent of manganese and iron, the latter being mechanically carried rather than chemically bound, the metal collects at the bottom of the cement furnace and is tapped off separately. Granulated slag is put in the cement furnace.—*Engineering* (London), July 15, 1921.

ELECTRIC DRIVING IN THE PAPER MILL ON HEAT ECONOMY LINES

THIS is an extensive paper contributed by Mr. A. B. Mallinson to the *Journal of the Institution of Electrical Engineers* for April, 1921.

The various uses for which steam is required in paper manufacture are first discussed. Then follow particulars of the various classes of machinery to be driven, and comments on the selection of suitable electrical gear. The heating requirements for heat economy, and the various types of power plant by which this can be attained are discussed in detail, together with recommendations on how each type of plant will be used for the different types of paper mills. The utilization of existing prime movers on "heat economy lines" is specially shown.

Next, the author takes up the factors governing the choice of electric supply and, finally, the driving of the variable-speed end of the paper machine proper is discussed in detail. The requirements for a successful drive are first enumerated, then various means of attaining that drive, not only with a single motor, but alternately with several motors are thoroughly canvassed.

The author's opinion is that electrification of existing machines will generally be on the single-motor system, as unless the gear at the back of the machine is worn out the expense of the multi-motor system cannot be justified.

For new machines, however, the multi-motor system has the following good points: (1) The cost of machine and drive is little, if any, more costly, no gearing being required. (2) With the extra-high-speed news machines now being developed, the gearing is getting almost beyond practical limits. (3) By cutting out the gearing, a narrower machine-house will suffice, thus making a marked saving in building and foundation costs. (4) When considering the installation of a new machine to replace an existing one, the multi-motor system will enable a wider machine (with consequent increased production to be placed in the same machine house, due to the reduced space required for the drive).

STREET LIGHTING

THE art of street illumination has considerably advanced during the last decade, its present state of development in this country is well described in a series of articles in the *General Electric Review* for August, 1921, which is a special street lighting issue.

Dr. Elihu Thomson writes on the evolution in street lighting. Probably no one is better fitted than Dr. Thomson to narrate the early history of street lighting. In his article, he first describes the conditions which existed during the successive periods when the fire brand, candle, oil lamp, and gas lamp were in turn the source of street illumination, and then reviews the various features in the development of the modern electrical system.

Dr. Louis Bell contributes a short article on the principles which govern the design and layout of street lighting systems. He divides installations into three classes: The first, important streets where the public congregates and traffic is congested; the second, thoroughfares which are of secondary importance; and third, residential streets and highways where traffic is light and police protection less essential. For each of these he names the amount and other requirements of the illumination, describes the means of securing the desired effects, and points out the fundamental faults that have prevailed.

Mr. W. D'Arcy Ryan, the intensive or super-white-way lighting. The first installation of this system of intensive lighting was made in October, 1916, in San Francisco, on Market Street. In less than five years the system has proved itself so attractive from the architectural, business building and protective standpoints that it has already been adopted by a number of other cities, and the idea is spreading rapidly. Mr. Ryan, who has always been an advocate of better lighted streets, presents in this article salient information as to the super-white-way system and the several existing installations.

Mr. A. F. Dickinson reviews the street lighting expenditures. Per capita expenditures in practically all municipal departments have greatly increased during the past decade. One exception has been street lighting. Ever-increasing traffic and the popularity of night recreation have so congested the streets of our cities that greatly-increased illumination has become a necessity. The author analyzes the division of the tax "dollar" and points out the fairness and economy of the assignment of a larger proportion of it to street lighting. By charts and tables he also presents per capita expenditures for street lighting by cities and by states so that one may locate at a glance sections of the country that are deficient or progressive in this respect.

Numerous other articles cover well the field of the street lighting distribution systems of the various fixtures and equipment. A reference list to street lighting literature for the period 1915-1921, contributed by the Main Library of the General Electric Co., concludes the issue.

TESTS OF THE EFFICIENCY OF ELECTRIC IRONS

THE irons were divided into five classes, according to the method of their construction, and the criterion adopted is the difference in temperature between the base and the upper part. The best efficiencies were obtained with the irons of class E. In these the heater is pressed against the base by a separate compression plate. Above the compression, but with an air space between there is a weight. The whole is covered by a sheet-iron cap which is thermally insulated from the base by an asbestos sheet and from the remaining parts of the iron by air insulation. In the tests the temperatures on the base and top were measured by thermo-electric couples.

The efficiency of the irons as a means of conducting heat to clothes is measured by various methods. According to one method the irons were placed on two sheets of soft asbestos moistened with water until the temperature of the latter reached 200 deg. Cent. The variation of temperature with time at the top and base of the five irons is given. Iron E heated the asbestos sheets to 200 deg. Cent. in 34 minutes, the other irons requiring from 43.5 to 49 minutes. Other methods of tests include three forms of water calorimeter.—*Elektrotechnische Zeitschrift*, January 20, 1921.

GROUND CHOKE COILS AS A PROTECTION AGAINST GROUND CURRENT AND OVERVOLTAGES

MR. R. BAUCH contributes a long theoretical treatise dealing with the action of a grounding choke coil. Without the use of such a coil a voltage of about four times the normal value has to pass through one phase of a three-phase transformer in case of a ground on one phase, which will in most cases cause a puncture. Connecting a grounding choke coil to the Y-point of the transformer will prevent the reflection back through the transformer with increased potential of a line disturbance caused by a ground on the line but will annihilate this oncoming energy and pass it to the ground. It is necessary, however, to have all this energy pass through the winding of the transformer. Its coils will not stand this stress if the overvoltage disturbance is backed by a large amount of energy. The grounding choke coil is therefore not suited for the safe annihilation of traveling waves. By means of theoretical calculations the author finds that it is much better to employ on a three-phase line three pole grounding coils instead of one Y-point choke coil. Such a pole ground should consist of a three-phase transformer with a fourth magnetic return, *i.e.*, a four-legged core. Its primary is star-connected with grounded neutral ;the secondary is an open delta, closed over a special regulating iron-core reactance. The author describes in detail laboratory experiments made with such "quenching" transformers using the oscillograph extensively to investigate its operation. Finally the actual construction of these transformers and their proper connection is given.—*Elektrotechnische Zeitschrift*, June 2 and 9, 1921.

Progress in Mining and Metallurgy

Abstracts of Recent and Coming Papers

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

ELECTRIC POWER A FACTOR IN THE ANTHRACITE FIELD

By W. A. Thomas

Steam is, and doubtless always will be, the basic power in the anthracite industry, either directly applied through engines and pumps or electrically. The rapidity with which electric power is being applied to the mining and preparation of anthracite leaves little doubt as to its utility and economy. There is practically no operation, except possibly the drilling of hard rock, that has not been successfully electrified and the matter of drilling is handled economically with electrically driven compressors and the standard compressed-air drills.

The reports available for the year 1920 indicate a production of slightly over 80,000,000 tons of anthracite, of which 8,843,500 tons were used for power and heating purposes; in other words, over 11 per cent of the production was used at the mines. Some of this was used to generate electric power at the mines, about 160,000,000 kw-hr., while 150,000,000 kw-hr. was purchased from the public utility companies.

A careful study of the field indicates that steam-operated plants use upward of 13 per cent of the production for power and heating, while electrically operated plants use about 1 per cent for heating; so that, for steam-power purposes at least 12 per cent, or 268.8 lb., are used for power out of each ton produced. Twenty kw-hr. per ton would be a conservative average value for electrified operations.

The large central station consumes from 3 to 4½ lb. of No. 3 buckwheat coal per kilowatt hour at the switchboard and 5 lb. per kilowatt hour at the mine metering point will more than cover the central-station requirement for delivered power. With 20 kw-hr. per ton, this gives us 100 lb. of fuel per ton production at electrified operations, as against 268.8 lb. per ton at steam operations; thus effecting a possible saving of 168.8 lb. per ton produced. It is assumed that 50,000,000 tons production may be practically electrified as the power becomes available with a possible saving of 3,767,000 tons of fuel, which can be released to the market.

In gaseous mines, it is not advisable to electrify the fans unless these are supplied with power from a plant on the property with reserve generator capacity or from a public utility service having two circuits to the service. This, of course, depends on the hazard involved from failure of the fan drive for short periods.

As to cost and operation before and after electrification, it is unfortunate that careful records are either not kept or are grouped with other subdivisions of production costs so that it is difficult to get many accurate comparisons of cost.

In one case complete data are available. The operation had two boiler plants, both with part of the steam driving direct-current generators and one having the usual nest of air compressors. In electrifying, it was necessary to install motor drive in the breaker and washery, replace a large breaker wash-water pumping station, build three converting substations, install several new hoists and pumps, and change the drive on steam and compressed-air hoists and pumps and fans. Separate job numbers were assigned to each installation, against which all charges were made for complete installation; on completion it was found that the total cost was not quite $125,000. This expenditure was made for an estimated saving of $44,600 per year; but before the year was up, 1917-1918, wages, fuel value, and for part of the year, power rates had advanced to such an extent that the actual saving was over $85,000 the first year.

In another case, a careful study shows that an expenditure of slightly over $900,000, not taking into account a considerable amount of good equipment that could be salvaged, would effect a possible saving in operating cost of $440,000 per year at the present public utility rates for electric power. This is typical of many cases where the gross annual saving, by complete electrification, will be at least 50 per cent of the cost of the change over and always makes possible a greater output, where this is limited by power equipment or power supply.

In this connection, it should be noted that complete electrification will show the greatest economy for the reason that, while partial electrification in many cases shows great saving, it does not reduce the total steam cost in proportion to the reduction in the steam load. The stand by losses, maintenance of plant and steam lines, and the labor in the fireroom handling of fuel and ashes, are seldom reduced in the same proportion as the load.

There is but one conclusion, and that has been reached by many producers: viz., electric power, when properly installed, is cheaper and much more flexible than steam in carrying on the mining and preparation of anthracite.

Emphasis should be placed on proper installation not only from an electrical engineering standpoint, but from a mining and preparation standpoint as well, in order to take advantage of the possible changes in the handling of the product by reason of the greater flexibility of electric power.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

GENERAL GEOLOGY OF CATORCE MINING DISTRICT

By Charles Laurence Baker

The district of Catorce, San Luis Potosi, ranks among the first half dozen silver-producing camps of Mexico. Mining has been more or less continuous there for the last 150 years. The large producing mines, Mapum, Mazapil, Palomas, Musquiz, Minas Virjas, now for the most part idle or abandoned, are grouped around the head of two valleys: one which drains to the west, falls 2000 feet in 4½ miles between the main Catorce and the western foot of the range and is characterized by steep canon walls; the other, east of the main town of Catorce, from which it is separated by a high divide, heads in a number of steep tributaries above the basin in which lies the town of Potrero, and flows nearly north for 10 miles to the northern base of the range; below Potrero it has for the most part gently sloping valley walls and a broad valley floor.

The Sierra Catorce is the highest range of the region, the summits reaching altitudes of over 11,000 feet. With the exception of a few cliffs of the erosion escarpment of the lower limestone and the canon walls below the main town of Catorce, which is the highest town in Mexico, the gently rounded slopes are characteristic of a maturely eroded mountain range composed of folded sedimentary rocks. As is usual in desert regions, the heavy-bedded limestones are the most resistant to erosive forces. Folded into anticlines, they form the mountain ranges; and the intermontane valleys and basins, originally carved out of less resistant shales, clays, marls and sandstones, are covered by debris forming a mantle with surface gradually rising upward toward the hills. In time, the debris buries in deposits formed from their own ruins, all but the highest summits of the original mountains; some of this region has already reached this stage. Most of the débris is firmly cemented by calcium carbonate (caliche). Solution of the limestone by meteoric waters afforded the supply of lime carbonate, which has been redeposited upon evaporation of the waters as a cement binding the boulders, pebbles, and finer detritus.

Metamorphic rocks are exposed in the canon from the main town of Catorce westward to near the canon's mouth. These are divided into two series. The relationship between the two is not known. The probably older series outcrops between the Purisima tunnel and the main town of Catorce. A less metamorphosed series probably forms a steeply dipping anticline with axis in the vicinity of the lower town of Catorce and outcrops between the Purisima tunnel and the exposure of the immetamorphosed sedimentaries near the mouth of the canon. The age of the metamorphics is not known; they might in part be as old as pre-Cambrian or as young as Jurassic.

Unmetamorphosed sedimentary rocks overlie the metamorphic rocks with strong angular unconformity. All the more productive ore deposits appear to be in the heavy-pedded limestone of these rocks, which is 900 to 1000 feet thick.

In general, the upper sedimentary series is folded into a rather broad dome. The strata dip westwardly from the upper town of Catorce and disappear under alluvium at the western foot of the ranges. Most of the upper town lies on a sunken block at or near the summit of the dome, the sides of the sunken block being formed by faults.

Basalt or basic andesite forms a plug about 1 mile northeast of the upper town. Porphyry dikes, probably of quartz monzonite or a related rock, cut the sedimentary series in a general north-south direction.

The primary gangue minerals are calcite, quartz, rhodochrosite, and possibly some others, including anhydrite. The primary ore minerals are mainly sulfides of iron, iron and copper, lead, zinc, arsenic, antimony and bismuth. Mercury sulfides are found south of the main district. Subsequent alteration of the sulfides formed, principally in the oxidized and leached zones, the haloid silver minerals, the double salts of silver, and possibly even more complex silver minerals.

The main deposits are fissure veins in the lower limestone. The intersections of veins were the sites of rich bonanza oreshoots. There are also quite a number of pocket deposits, as in the other regions of limestones in northeastern Mexico.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

SLUSH PROBLEM IN ANTHRACITE PREPARATION

By JOHN GRIFFIN

IN the preparation of anthracite, the modern breaker uses approximately 1 gal. of water per minute per ton of production per day. As this water leaves the breaker it contains from 4 to 15 per cent solids, by weight, and is then known as slush. None of the solids is larger than 3/32 in. in diameter.

Slush dams afford a fairly low-cost method of retaining the solids, to prevent pollution of streams, where the slush can be run to the dam by gravity. The retained solids, however, are so mixed with limes and fireclay that they cannot be utilized for fuel without further preparation. Settling tanks of various types were developed to recover as much of the solids as possible in a relatively dry condition, so that a large tonnage could be stocked on limited areas, but during the past two years several slush-recovery plants containing Dorr thickeners and classifiers have been installed.

The first plant for recovering the granular coal was installed in 1919, at a breaker producing 5000 to 6000 tons per day; its total cost was $16,738. The slush amounts to about 4000 gal. per min., contains about 5 per cent total solids and is made through a 3/64-in. round-mesh screen. The plus 60-mesh solids form about 40 per cent of the total solids, while those between 60 and 100 mesh amount to about 20 per cent more. When the breaker shipments average 5000 tons per day, 200 dry tons of solids are recovered from the slush at a total operating cost of from 9 to 10 cents per ton.

A plant installed in 1920 is recovering the granular solids from 2200 gal. per min. of slush made through a 1/16-inch round-mesh screen. After this plant had been in operation a few weeks, the bed of the stream for several miles below the breaker had become freed from the solids deposited and after 7 months no signs of deposit were apparent in the stream. Based on breaker shipment, the cost of preventing pollution is slightly under 1 cent per ton shipped, if the recovered coal is considered of no value.

If the recoverable coal in slush is converted into domestic fuel, it will add 9 per cent to the present domestic shipments of anthracite. If it is pulverized and used in mine boiler plants, it will produce 59 per cent of the power required to operate the mines and make available for other purposes about 5,600,000 tons annually of barley and rice coal.

Complete prevention of stream pollution, except under unusual conditions, may be obtained at a cost of 1 or 2 cents per ton of breaker shipments, if no value is placed on the recovered coal. If the recoverable coal is valued at 35 cents per ton, the coal recovered will pay the cost of recovery and of preventing stream pollution by the slush solids that, at present, have no commercial value.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

POWER INSTALLATION AT COVERDALE MINE

By CHARLES M. MEANS

A THOROUGHLY modern coal handling system has been installed at the Coverdale mine of the Pittsburgh Terminal R.R. and Coal Co., about 11 miles from Pittsburgh on the Montour R.R. Power is delivered to the mine at 22,000 volts, and is stepped down by three 833-kv-a., single-phase, 60-cycle, oil-insulated, self-cooled transformers to 2300 volts.

Direct current for the mine circuits is supplied by two motor-generator sets, which are arranged to operate singly or in parallel. The main switchboard has two panels for the feeder circuits to the mine. These circuits are carried down the airshaft in rigid iron conduits, which are clamped to the concrete shaft lining. The negative lines are connected to a permanent ground underneath the substation floor.

The hoisting equipment at the air shaft consists of a Vulcan hoist, with cylindro-conical drum, with herringbone gear drive from a 250-hp., 2200-volt, induction motor with wound rotor. The control equipment is so designed that the motor cannot be accelerated beyond a fixed rate. A Webb trip recorder gives at 24-hr. record of hoisting.

The main hoist is the first Ilgner-Ward-Leonard hoisting installation in the Pittsburgh district. The main shaft is of rectangular section with semi-circular ends and is concrete lined from the landing blocks to the collar, a distance of 340 feet. It is surmounted by a steel head frame, which forms part of the tipple structure. Each of the two hoisting compartments contain a Lepley self-dumping cage designed to carry two type, the equipment being installed in a brick building of two cars side by side on a single deck. The hoist is of the end-lift rooms placed parallel with the long dimension of the shaft. One room contains the hoist, the other contains the contractor panel, flywheel motor-generator set, slip regulator, etc.

The hoist drum is of the cylindro-conical type, having two cylindrical sections 9 feet in diameter, two conical sections, and one 11 ft. cylindrical section in the middle. It is driven, through single-reduction herringbone gears, by an 850-hp., 350-r.p.m., 600-volt, shunt-wound, direct-current motor, which receives power through a flywheel motor-generator set consisting of a direct current generator, exciter, and flywheel driven by a wound-rotor induction motor connected to the 2200-volt line.

The tipple is of substantial steel and fireproof construction. When dumped, the coal passes into weigh pans, then to the shaker screens or the mine-run chutes. Circular picking tables are used instead of the straight-away type, giving a compact arrangement. As far as practicable all wiring in the tipple is enclosed in rigid iron conduit and there are no open switches for the men to handle.

AUTOMATIC SUBSTATIONS USED IN COAL MINING

By R. J. WENSLEY

THE use of small substations for the supplying of 275-volt energy to the locomotive and cutting machines in coal mines

is a well-established practice. A few years ago, when labor costs were lower, these substations were located as near to the load as possible, and an operator was provided for each station. This practice has now become so expensive that substations are being located with reference to other mining machinery, such as hoists or pumps, so that one operator can look after both; sometimes the substation is operated by one whose duties make him traverse quite a large area. In such cases the interruption of alternating-current supply may produce a long interruption in the direct current, as the station cannot resume service until the operator reaches it, and such interruptions interfere seriously with production and may easily counterbalance the supposed saving gained.

The grouping of substations for convenience in operating may also result in excessive copper loss and consequently poor trolley voltage, with its attendant evils of low locomotive speeds and increased locomotive motor maintenance. The speed of the coal-cutting machines will also be reduced. By relieving the substation of its burden of the operating labor cost, the most economical location, from an electrical standpoint, may be chosen. The matter of machine insurance should also be considered. The saving in maintenance costs is often the smallest item, when considering the automatic substation as machine insurance. When the coils in a machine are roasted out, due to continued overload or to operation under abnormal alternating-current conditions, the loss in production will easily offset the repair bill in most instances. Automatic control allows the installation of the substation above ground, when the mine is not too deep, but the location depends largely on local conditions.

The most convenient method of automatic operation is by remote control through the high-tension feeder. For the most reliable operation, it is necessary that each substation have an independent feeder. Then, the stations may be started by closing the oil switch at the point of origin of the feeder; an ammeter installed at this point will show the attendant what is happening at the substation. If to reduce the first cost it is necessary to put more than one station on one feeder, a series of time-element relays can be used to start the machines at short intervals, to avoid the surge otherwise caused by simultaneously closing the starting switches of several sets. The stations may also be started by voltage relays connected to the trolleys and shut down by under-current relays in the machine circuits. This is a more expensive method and is warranted only when the power cost is high. Time switches may be used to start the stations according to a definite schedule if desired. Control may be had from pilot wires run to convenient points where attendants are always available.

There is a feeling among coal operators that automatically controlled substations are too expensive for the average mine. This is not at all true. A 200-kw. set with 2200-volt 60-cycle synchronous motor and 275-volt direct-current generator with manual switching would sell at the present time for approximately $6150. The same machine with the simplest type of automatic control will sell for approximately $8350. This difference of $2200 capitalized at 20 per cent per year will give an annual charge of $440, which is far less than the wages of a man to operate the station for even one shift per day. If the operating labor is kept below this point by giving only occasional attention to the station, serious interruptions are invited; moreover, the automatic station does the right thing at the right time much better than could possibly be done by manual operation.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

MECHANICAL MINING OF ANTHRACITE

By HERBERT D. KYNOR

THE term mechanical mining is used to indicate the series of operations that replaces the hand methods of mining. The paper describes the machines and the methods of using them in anthracite mining; it summarizes advantages and disadvantages of the various methods and conditions favorable and unfavorable to their operation, and gives statistics concerning these methods. It then draws the following conclusions:

1. *Value of Mechanical Mining in Thin Veins.*—In nearly every case, an economy results from the introduction of mechanical mining. Veins down to 24 inches thick may be worked economically by means of mechanical devices; whereas hand mining, with the possible exception of a few cases, cannot be economically carried on in coal as thin as this. This results in a considerable increase of workable coal areas in the northern anthracite fields, and tends to prolong the life of the industry and the conservation of natural resources.

2. *Increased Production per Miner.*—The production per certified miner from a mechanical-mining operation is from two to six times as much as from the hand-mining system; therefore, per given production, fewer miners are required. This point has particular value because the miner is a skilled or high-priced worker; also, the Pennsylvania state mining laws require that a miner must have at least two years' experience as a miner laborer before qualifying as a certified miner, which has a tendency to restrict the possible number of miners in the region. In addition, the work of the miner is less laborious when mechanical devices are used.

3. *Greater Output from Thin Veins.*—For a given area or a given amount of development, a far greater production per day is obtained from mechanical mining than from hand mining, due to the concentration of effort on a small area. This also facilitates the transportation and the incidental mine work. A steadier production is obtained from mechanical-mining units, as the coal is loaded out with few interruptions, while in hand mining a certain number of days in every period are employed in blowing and loading out or gobbing rock, which means the non-production of coal. By means of cross-over connections between gangway and airway, a number of mechanical mining units may be worked in the same section of the mine without interfering with one another, thus considerably increasing production.

4. *Greater Output per Employee.*—The output per employee for mechanical-mining operations is about 50 per cent greater in chamber work than hand chamber methods, and on longwall work as high as 300 per cent increase has been obtained. This, in itself, is a very important point in the favor of mechanical methods.

5. *Greater Prepared and Total Yields.*—Tests show that coal undercut by machine gives about 10 per cent more prepared yield than hand-mined coal. Jackhammer-mined coal blown off the solid does not give as good a prepared yield as hand-mined coal. As the speed of production is greater in the jackhammer method, the whole face is drilled at one time and fired, instead of only a few holes at a time, as in hand work. This does not permit the greatest care in the placing of holes and providing free breaking faces, as in hand mining.

6. *Percentage of Recovery.*—By mechanical-mining methods, where chamber-and-pillar work is done, the same amount of recovery can be made as in hand mining; in the longwall system of mechanical mining, 100% recovery is being made.

Generally speaking, mechanical mining has been introduced only in thin-vein work, or in thick-vein work where the physical conditions were abnormal and where it was impossible to secure men to work by the hand method. For this reason, there has been little opposition to the mechanical-mining method from the labor unions, but when the question of introducing mechanical mining into the thick seams is to be considered, as with the introduction of any machinery to replace hand work, means of controlling possible opposition on the part of the workman must be taken into consideration. If a virgin area of coal is to be worked, due consideration should be given to the introduction of mechanical methods for the entire mining of this coal, which undoubtedly under normal working conditions will result in quicker extraction, increased output per employee, and quicker returns on investment.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

Pumping Chemicals

OUT of 465 pumps found in plants based on chemistry, 114 were Worthington, while the next make in popularity numbered only 61—a little over half the number of Worthington pumps. In other words, this shows one Worthington in every four pumps and a preference of two to one in favor of Worthington against the next in line.

These plants where the pumps were found are the kind where pumping is most difficult. Half of all the pumps were handling refinery oils—often mixed with acids, caustic solution, and various acids. Certainly this shows exacting pumping conditions.

These figures are the result of an investigation in which the Worthington Pump and Machinery Corporation took no part—in fact Worthington did not even know of the investigation until it was completed.

And the Worthington preference was one in four against the field, two to one against the next best.

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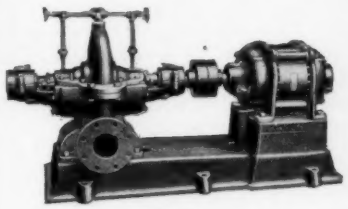
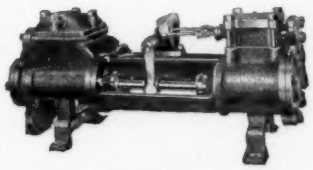
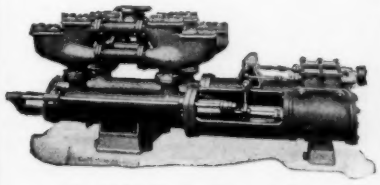


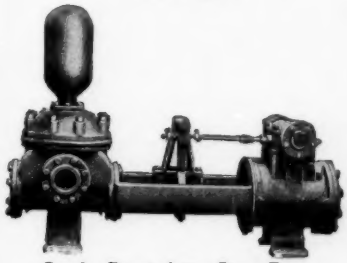
Motor Driven Double Suction Volute Centrifugal Pump



Duplex Direct Acting Piston Steam Pump



Pot Valve Duplex Direct Acting Steam Pump



Simplex Direct Acting Steam Pump

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Hazleton Works, *Hazleton, Pa.*

Gas Engine Works, *Cudahy, Wis.*
Power & Mining Works *Cudahy, Wis.*
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